

## **Emerging haptically-enabled systems for immersive simulation-based training: Design, Development, and Deployment**

Simulation-based training (SBT) is on the cusp of offering a cost-effective regime for administering realistic and safe training in a virtual environment across a wide range of sectors. In SBT, the immersion factor is of prime concern to ensure efficacy of skill learning. Nowadays, emerging technologies, including virtual/mixed reality (VR/MR) and artificial intelligence (AI), have dramatically improved the immersive quality of SBT tools, providing AI-based smart interfaces with high-fidelity 3D visual and auditory experiences to users (trainees). While VR/MR systems offer effective visual cues, they often are unable to provide realistic tactile sensation when interacting with virtual objects for performing dexterous tasks in SBT.

This lecture will explicate the integration of haptic (force feedback) technology into VR/MR systems to increase their fidelity for SBT. Through this innovation, a user is able to “touch-and-feel” virtual and/or remote objects, and perceive their attributes via haptically-enabled VR/MR systems. As such, the user can feel the object properties, such as texture or hardness/softness characteristics, when utilising these haptically-enabled SBT tools in an immersive environment for skill acquisition.

This lecture will focus on the design and development of a series of haptically-enabled systems, particularly haptically-enabled motion simulators, firefighting trainers, and tele-healthcare robotic systems, for SBT purposes. Serving as a flight/vehicle simulator, the developed robotic-based platform is integrated with haptically-enabled peripherals, such as haptic chairs and haptic control devices, to offer a high-fidelity training environment. The user can enjoy realistic flying/driving experiences, e.g., air turbulence or rough terrain, during training. On the other hand, the haptically-enabled hot-fire trainers enable the user to experience realistic jet reaction forces from the hose and provides immersive water dispersion and interaction with fire and smoke particles based on accurate physics modelling via the VR/MR-based tools. In addition, a haptically-enabled ultrasound scanning system for tele-healthcare applications will also be exemplified. It allows the user (sonographer) to remotely “touch-and-feel” the anatomical structure of a patient during tele-scanning, allowing accurate diagnosis of patients in tele-health services.

A series of demonstration of these haptically-enabled systems will be presented during the lecture. Successful deployment of several developed systems in real-world environments through start-up companies will be illustrated. The impact of these emerging haptically-enabled system to realise the next generation of SBT tools for immersive and personalized training in various sectors, including aviation, automotive, healthcare and emergency services, will be discussed.