CHALLENGES & OPPORTUNITIES SIMULATING FUTURE COMBAT SYSTEMS VIA MIXED REALITY

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The University of Central Florida is investigating the application of recent developments in Mixed Reality (MR) to integrate Virtual, Live and Constructive Simulation. From the "ground truth" of Military Operations in Urban Terrain (MOUT), to the extended dynamics of Virtual Reality and compelling engagement of experiential entertainment, Mixed Reality leverages advances in art, science and technology to help bring a seamless integration of physical reality enhanced with synthetic entities and the power of imagination to better prepare the soldier of the future in a physically, mentally and emotionally demanding theater of war.

With Mixed Reality still in its infancy, there are major scientific challenges to be overcome to make this technology fulfill its promise. In the Mixed Reality Innovation Testbed, an integrated team of artistic, scientific and training experts develop algorithms and new forms of content to create and evaluate Mixed Reality in diverse applications. This paper focuses on three challenges: registration and tracking for which there is a critical need for efficient algorithms, audio enhancement, an often ignored factor in making mixed reality effective, and show effects, in which lesson learned from theme parks are applied to MR.

Registration and Tracking.
State-of-the-art MR systems achieve blending of the real and virtual using an optical see-through Head-Mounted Display (HMD) with virtual objects inserted into the visual field, or a video see-through HMD in which the real world seen through cameras on the HMD is augmented with virtual objects [1, 2]. The process of placing these virtual objects in correct relation to real objects is the *Registration Problem*. The process of determining the user's position and orientation in real space is the *Tracking Problem*.

While optical see-through improves the quality of the user's view of the real world, it limits the use of hybrid tracking and registration techniques that depend on understanding the user's view. Tracking is imprecise when done using any single method, e.g., magnetic, inertial, optical or GPS. The viewer's location and viewing direction provide insufficient information to properly sort virtual and real objects, when the real objects are not fixed in space. Thus, determining the depth of physical objects relative to the viewer is necessary to properly determine mutual occlusion of real and virtual objects. These problems are challenging in controlled indoor settings and even more daunting in outdoor environments, such as MOUT facilities.

We attack the registration and tracking problems by using knowledge of static objects (e.g., buildings, walls) in the real world (as is possible in a MOUT site or a dedicated laboratory), physical markers added to the real scene, and a tracking system. The tracking system provides an initial imprecise estimate of the position of the viewer (orientation is generally more precise) [3, 4]. Real-time algorithms then determine which static real world objects and which markers are potentially visible [5, 6], and prior knowledge of their positions is used to refine initial tracking estimates. Positional information of non-static objects is calculated using their positions relative to static objects and their depth from the viewer using "depth from stereo" techniques common to computer vision.

Audio.
Delivery of realistic sounds during live combat simulation is essential to both the training of situational awareness and the trainees' adaptation to the expected stress level. Grenade simulators and blank rounds are standard tools. However in a mixed virtual/live simulation, the computer generated forces moving through the MOUT site cannot depend strictly on firing real ordnance simulators at fixed locations – because the forces' locations depend on the flow of the scenario. In addition, armor, aircraft, breaching rounds and other sources of large audio events are not only difficult to simulate, they need to seamlessly match the dynamic reality. Theme parks and other outdoor

environments are equipped with powerful and realistic electronic audio systems, providing us with a guiding but incomplete model to enhance MR experiences.

Sophisticated techniques exist for the creation of "surround sound" audio when the location of the listener within the speakers' sound field is known and fixed. When multiple listeners are spread across a changing environment, the problem is harder. When both sound sources and hearers are moving, the problems are unsolved. Our goal is to develop, prototype and test a system to deliver the sounds that a squad of infantry would normally expect to hear when clearing a defended building. These sounds will range from footfalls and other signs of furtive movement as well as speech and shouting by civilians and hostiles, to hostile small arms fire and larger explosions such as grenades. These sounds will be controlled by a script execution system that is directing an augmented-reality scenario. A critical feature is that the soundscape should not be built around a fixed "sweet spot" (as occurs with traditional surround-sound programming), but should have an acceptable level of realism from any location a soldier is likely to go to.

Show Effects.

Combining simulation and modeling techniques of MR and theme park physical special effects technology can provide the users a multi-sensory interactive environment more closely representing ground truth of live simulation integrated with the dynamics of virtual scenarios. The concept is to create devices called macro-stimulators that form a network of reconfigurable and reprogrammable special effects. These effects are managed by a central show control system. Effects are initiated by input from the virtual scenario and sensor feedback of the instrumented simulation sites (e.g., a MOUT facility). This provides a more compelling and disorienting ground truth, and helps bridge and blur the gap between what is virtual and what is real

The problem with directly using existing theme park techniques is that special effects are designed for specific purposes and are not dynamic enough to provide a wide spectrum of effects. In addition, show control systems are designed to function within linear scenarios that have limited interactivity and are not intended to be reprogrammable or scalable. The challenge presented in this work is to incorporate show control systems to activate a variety of programmable special effects (sound, show action, light, pyrotechnics, etc.) in response to user actions and in support of the goals of the simulation (e.g., task training, situational awareness). Scalability and adaptability of this approach requires that these show control devices plug into a computer network controlled by an interactive simulation scenario.

Summary.

We have described problems related to the effective use of MR and posed several approaches to overcome these problems. Our work is leading to the development of algorithms, tools, techniques and creative adaptations of theme park technology. These results support our interdisciplinary approach, combining the strengths of artists, scientists and experiementalists.

References

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