Creation of Augmented Virtual Environments by Dynamic Fusion of Imagery and 3D Models

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Extended Abstract

The rapid and reliable creation of realistic three-dimensional environment models is vital to virtual environment (VE) applications in engineering, mission planning, training simulations, entertainment, or tactical decision making and military operations in battlefield environments. While current sensing and modeling technologies offer useful methods for VE creation and visualization, several significant limitations remain. First, most modeling systems facilitate geometric modeling through the manipulation of either standard geometric primitives, libraries of pre-modeled objects, or manual digitizing of key points. Creating models of a large environment in this fashion takes enormous effort, skill, and time, resulting in not only high costs inhibiting the broad use of such models, but also making it burdensome to update and modify the models. Second, while most systems support texture mapping, they are limited to static texture databases that must be created prior to use. Static textures are usually derived from fixed cameras at known or computed transformations relative to the modeled objects. Once their relationships are established, the texture images are mapped to the geometric models during scene rendering. Such static texture-maps are limiting for applications requiring a dynamic and up-to-date picture of the environment. In time-critical applications, such as military command and control, person or vehicle tracking, and catastrophe management, a rapid and accurate fusion of dynamic appearance and geometric data is critical. Real time video or other sensor data needs to update the VE models. There is little or no support for dynamic spatio-temporal update in the current structure of VE models, databases, and rendering systems.

To cope with the aforementioned limitations of static models and visualizations of environments, we introduce the concept of an *Augmented Virtual Environment* (AVE) that has the capability to capture, represent, and visualize dynamic spatio-temporal events and changes within a real environment. The AVE is a virtual-reality augmented by the fusion of dynamic imagery onto the 3D model, providing a unique approach to visualize and comprehend multiple streams of temporal data and imagery (video and still images) in time-critical applications. We have developed approaches towards the system requirements we consider essential to an AVE. The core techniques we developed and integrated include model reconstruction, model refinement, building extraction, sensor tracking, real-time video/image acquisition, and dynamic texture projection for 3D visualization.

In this presentation, we will present novel methodologies for the rapid creation of realistic geometric models from LiDAR data and their dynamic refinement and update from multiple sensor sources. We demonstrate our hybrid 6DOF tracking system with integrated GPS, inertial, and vision tracking technologies and applied these for dynamic data fusion and sensor registration. The introduction of the tracked-sensor data into the VR database enables the imagery to be decoupled from the geometry thereby enabling the dynamic system update and modification. We also present methods to fuse multiple streams of dynamic video imagery on the 3D model substrate to provide a coherent data visualization that enhances scene comprehension, object tracking, event detection, and information extraction. We have integrated these components into a prototype AVE system and present results that illustrate the utility and benefits of an augmented virtual environment.

Above figure illustrates an AVE scenario of fusion multiple simultaneous video streams within one campus area to create a dynamic immersive 3D visualization. In this figure, the top-left window shows the novel view of three live video streams are fused with the 3D geometric building models extracted from USC campus LiDAR dataset, and the rest three windows show the rendered views from the three video sensor viewpoints, respectively.

Detailed information of the research can be found at our website: http://graphics.usc.edu/~suyay/muri/muri-home.html.