



R&D Projects in VR 2007

**Fundamental Theory,
Algorithms and Application**

R&D Projects in VR

- **Realism Modeling & Real-time Rendering**
 - Complex, natural scenery
 - Image-based modeling and rendering
 - Out-of-core model rendering
- **Multi-modal Interaction/Simulation**
 - Touch-enabled VR environments
 - Interactive surfaces using Wavelets
 - Virtual medicine simulations
- **Augmented image/video processing**
 - Retexturing/constrained texturing
 - Dynamic texture synthesis
 - Interactive Fur with self-shadows

Realism Modeling & Real-time Rendering

- Realistic rendering of highly complex, natural scenery involving trees, plants, snowy/windy effects plays important role in VR applications
- 3D scanners generate highly detailed models with the huge set of point samples, so non-trivial to reconstruct with high efficiency and rendering qualities
- Huge meshes are out-of-core, and pose real challenges for efficient display, processing, transmission and storage

Complex, natural scenery

- Hybrid multi-mapping approach for realistic snowy natural scenery
 - Volumetric textures, displacement maps
 - Reproducing natural beauty efficiently
- Anti-aliased shadow mapping for real-time large-scale, dynamic scenes
 - Parallel-split shadow maps
 - Shadow-mapping reparameterizations
 - Enhanced qualities of shadow rendering

Complex, natural scenery



Image-based modeling and rendering

- Image synthesis from multi-reference images in IBMR for novel viewpoints
- Ref-image searching is accelerated by pixel ordering on epipolar lines
- Reconstruction of complex scenes from image sets for real-time walkthrough

Out-of-core model rendering

- Use clustering, filtering and splitting to simplify out-of-core huge meshes
- Manifold topology of the simplified meshes is guaranteed for post-processing and rendering

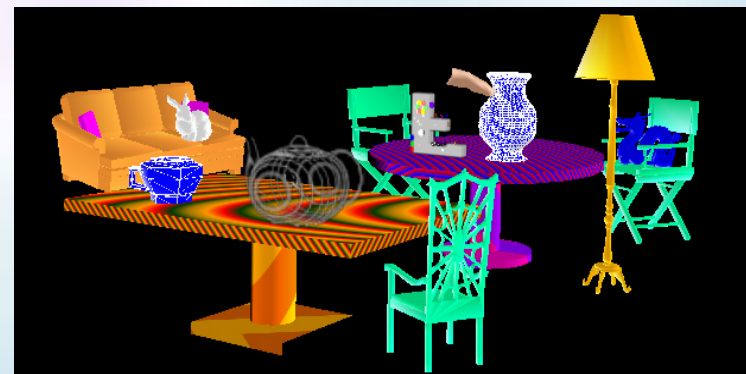
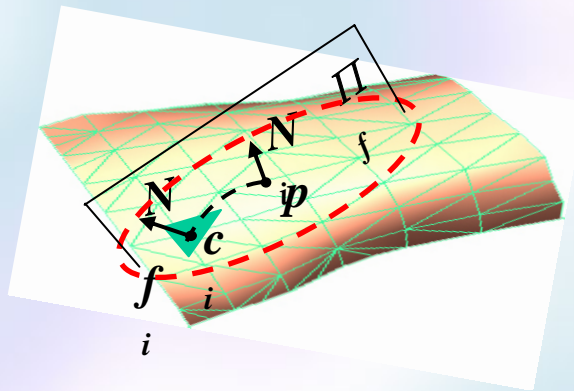


Multi-modal Interaction/Simulation

- Haptics interfaces present challenges in data processing analysis, physical modeling, interactive visualization, dynamic simulation
- Subdivision surfaces are motivated to uniformly model complex surfaces of arbitrary topology without losing efficiency and quality
- Modeling of soft-tissue deformation is of great importance to VR-based medical simulations, cost effective surgical training involving such operations.

Touch-enabled VR environments

- Body-based haptic interaction model that simulate the realistic tool-object sensations in virtual environments
- Interactive haptic modeling incorporating the dynamic simulation of MSS and flexible control of FFD
- Unified haptic navigation in level-of-detail virtual scene descriptions consisting of hybrid models



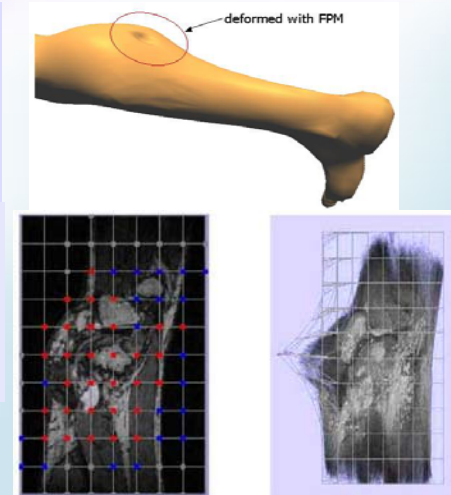
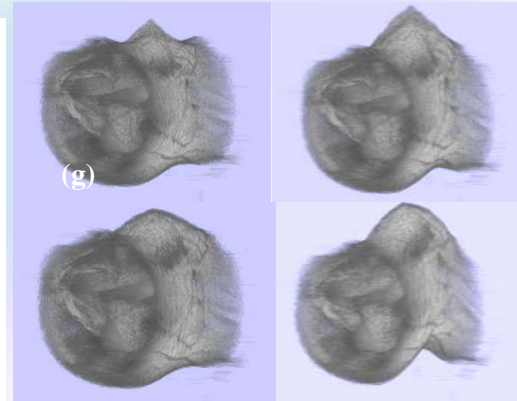
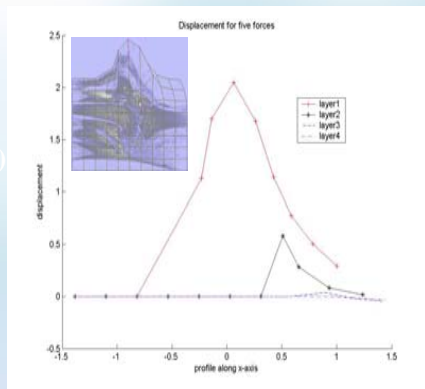
Interactive surfaces using Wavelets

- Unlifted Loop subdivision wavelets provide efficient (linear time and fully in-place) computations for wavelet transforms
- Biorthogonal subdivision wavelets based on the lifting scheme can be applied for multi-resolution processing analysis of closed and open triangular meshes
- Our wavelet approach supports efficient analysis and synthesis of dynamic Loop subdivision wavelets in the texture memory

Virtual medicine simulations

- Soft-tissue deformable model of medical datasets has demonstrated typical tissue responses and anisotropic behavior
- Simulated annealing algorithms developed to optimize the model parameters corresponding to different tissue stiffness
- Multi-threaded computing of haptic simulation realized for the typical behavior of living tissues and anisotropic materials in real-time

Multi-modal Interaction/Simulation



Augmented image/video processing

- Texture synthesis capable of producing similar textures exhibiting continuous changes in orientations and scales from simple samples
- Dynamic textures represent such textured surfaces with repetitive, time-varying visual patterns that exhibit stationarity properties
- Furry surfaces are crucial representing the realistic appearance of virtual humans and animals, in virtual environments

Retexturing/constrained texturing

- Model the textured smooth variations of orientation/scale in arbitrary 3D surfaces guided by user input
- Stretch-based mesh parametrization for perspective foreshortening and large distortion, and Poisson-based refinement for distortion at fine scale
- Local and global optimizations are designed for accurate and smooth motion info. of dynamic objects



Dynamic texture synthesis

- Our approach to synthesize dynamic color textures by compressed the UV channels to reduce the size of matrix computation using LP and RBF
- RBF-based DCTS is memory efficient and can better capture the dynamic behavior using the time correlation
- Conduct on a comparative study on different multi-resolution descriptors (LP, HW, SP) to improve the DCT synthesis results

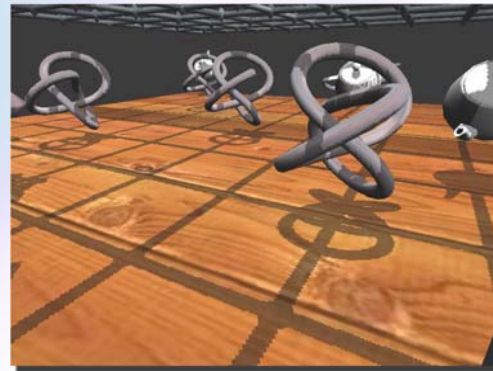
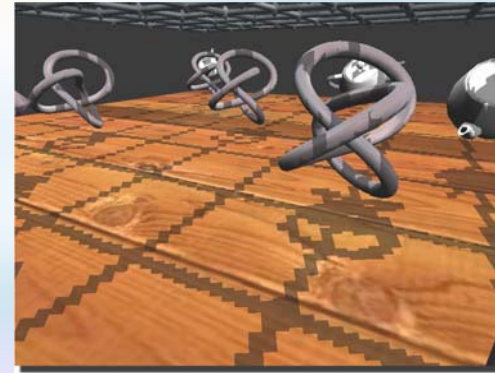
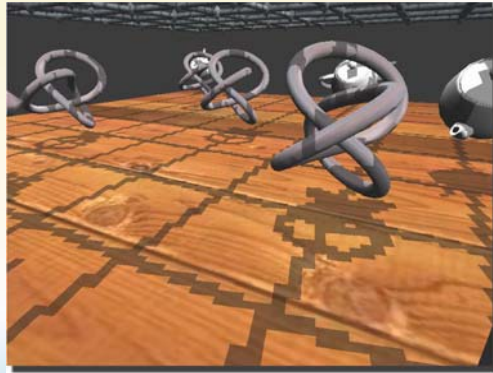


Interactive Fur with self-shadows

- To enhance the realistic fur rendering, layered shadow maps developed to simulate the self-shadowing effects
- Interactive editing tools to intuitively control and manipulate the fur shapes over the model surfaces, using the dynamic surface-field strategy



Video Demo





Thank you

In collaboration with
Tsinghua University, Beijing
Zhejiang University, Hangzhou
Chinese Academy of Sciences, CAS
University of Macau, Macau