University of Victoria | Graduate Studies

PROGRAMME

The Final Oral Examination
for the Degree of

DOCTOR OF PHILOSOPHY
(Computer Science)

Pourya Shirazian

2008 Iran University of Science and Technology MSc
2005 Azad University of Tehran BSc

"**High Performance Animation of Soft Tissues**"

Friday, December 12, 2014
1:30p.m.
Engineering Computer Science (ECS)
Room 468

Supervisory Committee:
Dr. Brian Wyvill, Department of Computer Science, UVic
(Supervisor)
Dr. Paul Lalonde, Department of Computer Science, UVic
(Department Member)
Dr. Roy Eagleson, Faculty of Engineering,
University of Western Ontario (Outside Member)

External Examiner:
Dr. Hao (Richard) Zhang, School of Computing Science
Simon Fraser University

Chair of Oral Examination:
Dr. Aaron Devor,
Department of Sociology, UVic

Abstract

A surgical simulation system requires models of elastic material to behave accurately, to appear as realistic as possible, and allow interaction that can deform and change the topology of the model. For example pushing on a model should produce physically accurate deformations without changing the topology. A cutting operation is more complex as it requires the topology to change. Both of these procedures are required for surgical scenes in order to bring those models to life sufficiently to be useful for surgical planning or training. In this research we propose a comprehensive framework for high-performance rendering and physically-based animation of deformable tissues using implicit surfaces. Our system provides an interactive cutting ability using smooth intersection surfaces. Complex models can be created with implicit primitives, blending operators, affine transformations, deformations and constructive solid geometry in a design environment that organizes all these in a scene graph data structure called the BlobTree. We show that the BlobTree modelling approach provides a very compact data structure which supports the requirements above, as well as incremental changes and network-based cooperative design. A GPU-Assisted surface extraction algorithm is proposed to support interactive modelling of complex BlobTree models. Using a finite element approach we discretize those models for accurate physically-based animation. Interactions with the model are supported through smooth cut surfaces. We show an application of our system in a human skull craniotomy simulation.

Awards, Scholarships, Fellowships

2009-2010 -- Graduate Student Fellowship, University of Victoria
2008 -- Graduate Student Research Grant, Iran Telecom Research Center, Ministry of Information and Communication Technology (Iran)

Presentations

1. Shirazian, P., “Real-time physically based animation of implicit surfaces with finite element methods on the GPU”. Graphics, Animation and New Media (“GRAND”) NCE AGM, Toronto, Ontario, Canada, May 2013. (oral)

2. Shirazian, P., “Polygonization of implicit surfaces on Multi-Core Architectures with SIMD instructions.” Eurographics Symposium on Parallel Graphics and Visualization, Cagliari Italy, May 2012. (oral)

3. Shirazian, P., “Parallel Computing Techniques in Rendering Complex Implicit Models.” Graphics, Animation and New Media (“GRAND”) NCE AGM, Montreal, Quebec, Canada, May 2012. (oral)

Publications

1. Shirazian, P., Wyvill, B., Eagleson, R., & DeRibaupierre, S. “GPU-Accelerated Craniotomy Simulation”, Methods in Biomechanics and Biomedical Engineering (CMBBE): Imaging and Visualization Journal, **2014**. (Submitted to a journal)

2. Shirazian, P., Wyvill, B., Eagleson, R., & DeRibaupierre, S. “Interactive Cutting for Surgical Simulation Systems.” Graphics, Animation and New Media (“GRAND”) NCE AGM, **2014**. (poster)

3. Shirazian, P., Wyvill, B., Eagleson, R., & DeRibaupierre, S. “Realtime physically based animation of implicit surfaces with finite element methods on the GPU”. Graphics, Animation and New Media (“GRAND”) NCE AGM, **2013**. (poster)

4. Grasberger, H., Shirazian, P., Wyvill, B., & Greenberg, S. “A data-efficient collaborative modelling method using websockets and the BlobTree for over-the air networks.” Proceedings of the 18th International Conference on 3D Web Technology - Web3D ’13, 29, **2013,** 29-37.

5. Shirazian, P., Wyvill, B., & Duprat, J.-L. “Polygonization of implicit surfaces on Multi-Core Architectures with SIMD instructions.” In Eurographics Symposium on Parallel Graphics and Visualization, **2012,** 89-98.

6. Shirazian, P., Wyvill, B., & Duprat, J.-L. “Parallel Computing Techniques in Rendering Complex Implicit Models.” Graphics, Animation and New Media (“GRAND”) NCE AGM, **2012**. (Research Note)

7. Shirazian, P., Wyvill, B. “Parsip: An Implicit Surfaces Polygonizer for Multi-Core Achitectures.” Graphics, Animation and New Media (“GRAND”) NCE AGM, **2010**. (Research Note)