Computer Graphics Laboratory

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The Computer Graphics Lab conducts research into physics-based modeling of different phenomena, their visualization and animation. Innovative approaches to graphical user interfaces and direct interaction methods, modeling, rendering, simulation and scientific visualization are under development. Created mathematical models are used for graphical representation of natural processes.

Research areas include:

- Visualization of surface and volume data, which results from finite element, boundary element and finite difference modeling.
- Nanomechanics modeling. Finite element and molecular mechanics modeling of micro- and nanostructures.
- Augmented reality interface for different fields of human activity.
- Using graphics processing units for physics-based modeling and animation.
- Development of algorithms for shape modeling, analysis and understanding (operations on shape, segmentation and reconstruction).
- Investigation of algorithms for the polygonization of implicit surfaces (adaptative and robust polygonization, fast polygonization).

Professors of the Computer Graphics Laboratory deliver courses in Computer Graphics, Numerical Analysis, Modeling and Visualization. Graduation projects are related to computer graphics, human-computer interaction, physics-based modeling, visualization, and animation.

Summary of Achievement

Refereed Journal Papers

Refereed Proceeding Papers

[fayolle-03:2012] A. Belyaev, P.-A. Fayolle, and A. Pasko. Signed Lp-distance fields. In *Symposium on Solid and Physical Modeling*, pages 523 – 528, 2012.

We introduce and study a family of generalized double-layer potentials which are used to build smooth and accurate approximants for the signed distance function. Given a surface, the value of an approximant at a given point is a power mean of distances from the point to the surface points parameterized by the angle they are viewed from the given point. We analyze mathematical properties of the potentials and corresponding approximants. In particular, approximation accuracy estimates are derived. Our theoretical results are supported by numerical experiments which reveal high practical potential of our approach.

[niki-02:2012] Gennadiy Nikishkov. Estimation of geometry effect on Jc using two-parameter description of crack-tip fields. In *International Computational Mechanics Symposium ICMS2012*, pages MS4–1–3, Kobe, Japan, 9–11 October 2012.

The J-integral fracture criterion based on single-parameter description of the crack-tip stress fields can lead to significant errors in predicting failure loads of elastic-plastic bodies. The three-term asymptotic expansion represents crack-tip fields much better using an additional amplitude parameter A. This paper shows that the J-A description of the crack-tip fields and the weakest link model allow estimation of the geometry effect on fracture toughness by treating the parameter A as geometry constraint. Values of small scale yielding parameter Assy and dependencies Jc(A)/JIc are approximated by empirical functions for elastic-plastic materials with different hardening powers. This approach allows development of fracture analysis procedure for cracked structures with different geometry constraints without additional experimental tests.

Chapters in Book

[niki-03:2012] Y.Nishidate and G.P.Nikishkov. *Continuum and atomic-scale finite element modeling of multilayer self-positioning nanostructures*, pages 185–

240. Computational Finite Element Methods in Nanotechnology. CRC Press, Boca Raton, 2013.

The self-positioning is a phenomenon that occurs in structures which are subjected to a strain/stress imbalance. Multilayer thin films consisting of different materials are rolled-up and form nanohinges and nanotubes. Complicated three-dimensional nanostructures can be fabricated by utilizing the self-positioning phenomenon. In this research, modeling of the self-positioning nanostructures is performed by the continuum mechanics theory, the finite element method, and the atomic-scale finite element method taking into account cubic crystal anisotropy. The continuum mechanics solution has been derived for multi-layer thin film structures subjected to initial strains under generalized plane strain conditions. The finite element modeling has been applied for estimation of the curvature radius of self-positioning hinges. An atomic-scale finite element procedure has been developed for modeling of self-positioning nanostructures. The results are compared with each other through modeling of bi-layer self-positioning nanostructures.

[nisidate-01:2012] Y. Nishidate and G. P. Nikishkov. *Continuum and Atomic-Scale Finite Element Modeling of Multilayer Self-Positioning Nanostructures*, chapter 6. Computational Finite Element Methods in Nanotechnology. CRC Press, Broken Sound Parkway NW, 2012.

Grants

[nisidate-02:2012] Y. Nishidate. Kanto Bureau of Economy, Trade and Industry, 2012.

Academic Activities

[fayolle-04:2012] P.-A. Fayolle, 2013.

Member of the Program Committee for the conference Shape and Modeling International 2013

[fayolle-05:2012] P.-A. Fayolle, 2012.

Reviewer for the conference Pacific Graphics 2012

[fayolle-06:2012] P.-A. Fayolle, 2012.

Reviewer for the journal Computer-Aided-Design

[fayolle-07:2012] P.-A. Fayolle, 2013.

Reviewer for the conference Computer Graphics International 2013

[niki-04:2012] Gennadiy Nikishkov, February 2013.

Member of the Program Committee, Int. Conf. on Computer Graphics Theory and Applications GRAPP 2013, Barcelona, Spain.

[niki-05:2012] Gennadiy Nikishkov, 2012.

Member of the Editorial Board, International Journal 'Computer Modeling in Engineering and Sciences'.

[niki-06:2012] Gennadiy Nikishkov, April–May 2012.

Member of the International Organizing Committee, Int. Conf. on Computational and Experimental Engineering and Sciences ICCES 2012, Crete, Greece.

[niki-07:2012] Gennadiy Nikishkov, June 2012.

Member of the Program Committee, IASTED International Conference on Computer Graphics and Imaging (CGIM 2012), Crete, Greece.

[niki-08:2012] Gennadiy Nikishkov, September 2012.

Member of the Editorial Board, The Eleventh International Conference on Computational Structures Technology CST 2012, Dubrovnik, Croatia.

[niki-09:2012] Gennadiy Nikishkov, 2012.

Reviewer, Computer Modeling in Engineering and Sciences.

[niki-10:2012] Gennadiy Nikishkov, 2012.

Reviewer, The Arabian Journal for Science and Engineering, Springer.

[niki-11:2012] Gennadiy Nikishkov, April 2013.

Member of the Editorial Board, The Third International Conference on Parallel, Distributed, Grid and Cloud Computing for Engineering PARENG 2013, Pecs, Hungary.

[nisidate-03:2012] Y. Nishidate, 2012-2013.

平成２５年度電気関係学会東北支部連合大会 2013, 実行委員

[nisidate-04:2012] Y. Nishidate, June 2012.

Reviewer, Journal of the Optical Society of America A

[nisidate-05:2012] Y. Nishidate, 2012-2013.

可視化情報学会全国講演会 2013, 幹事

Ph.D and Others Theses

[fayolle-08:2012] Takahiro Inagawa. An Android Application for Virtual Cloth Try On, School of Computer Science and Engineering, 2013.

Thesis Advisor: Pierre-Alain Fayolle

[niki-12:2012] Yuhei Suzuki. Graduation Thesis: Rendering 3D objects with environment mapping using OpenGL shading language, University of Aizu, 2013.

Thesis Advisor: Gennadiy Nikishkov

[niki-13:2012] Yuya Tamaru. Graduation Thesis: Comparison of WebGL and OpenGL in 3D Computer Graphics, University of Aizu, 2013.

Thesis Advisor: Gennadiy Nikishkov

[niki-14:2012] Takaaki Fukasawa. Graduation Thesis: AR ball game with physics modeling, University of Aizu, 2013.

Thesis Advisor: Gennadiy Nikishkov

[niki-15:2012] Ryo Kawamukai. Graduation Thesis: Water wave simulation using CUDA, University of Aizu, 2013.

Thesis Advisor: Gennadiy Nikishkov