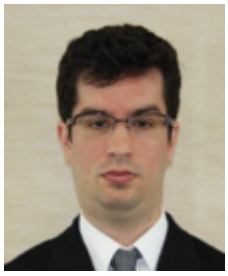
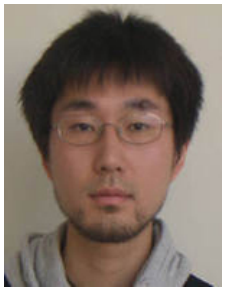
Computer Graphics Laboratory

Shigeo Takahashi
Professor



Pierre-Alain Fayolle
Associate Professor



Yohei Nishidate
Associate Professor

Laboratory information:

Members of the Computer Graphics Laboratory conduct research into physics-based modeling of different phenomena, visualization and shape modeling. Innovative approaches to graphical user interfaces and direct interaction methods, modeling, rendering, simulation and visualization are under development. Created mathematical models are used for graphical representation of natural and complex phenomena.

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.
- Ray-tracing simulation for lens design.
- 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).
- Topological data mining/representation for scientific/mathematical visualization.
- Visual representation of texts and networks for information visualization.

- Map schematization including 2D railway maps, 3D urban maps, map annotations, aesthetic designs, etc.
- Modeling human visual perception and its application to visual analytics.

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

Refereed academic journal

[fayolle-305-013-01:2017] Alexander Belyaev and Pierre-Alain Fayolle. On modified Gordon-Wixom interpolation schemes and their applications to nonlinear and exterior domain problems. *Numerical Algorithms*, 77(3):691–708, 2018.

We introduce and study extensions and modifications of the Gordon-Wixom transfinite barycentric interpolation scheme (Gordon and Wixom, SIAM J. Numer. Anal. 11(5), 909-933, 1974). We demonstrate that the modified Gordon-Wixom scheme proposed in Belyaev and Fayolle (Comput. Graph. 51, 74-80, 2015) reproduces harmonic quadratic polynomials in convex domains. We adapt the scheme for dealing with the exterior of a bounded domain and for the exterior of a disk, where we demonstrate that our interpolation formula reproduces harmonic functions. Finally, we show how to adapt the Gordon-Wixom approach for approximating p-harmonic functions and to derive computationally efficient approximations of the solutions to boundary value problems involving the p-Laplacian.

[nisidate-305-013-01:2017] Y. Nishidate and I. Khmyrova. Numerical Procedure for Modeling of Light Emitting Diode with Mesh-Like Electrode. *Journal of Physics: Conf. Ser.*, 936:012010, 2017.

A computational procedure is presented for numerical modeling of the light emitting diode (LED) with top p-electrode designed as a mesh with the strips of rectangular cross section. Isotropic light emission in the LED's active region and light reflection from the bottom electrode are considered. Three-dimensional Laplace equation for electric potential is solved by finite element method. The numerical model incorporates mapped infinite element to account for potential decay far away from the LED structure and finite element model developed for boundary condition at semiconductor-air interface in the mesh opening. Simulation results demonstrate the effect of the mesh's geometrical parameters on the total output power.

[shigeo-305-013-01:2017] H.-Y. Wu, S. Takahashi, and R. Ishida. Overlap-Free Labeling of Clustered Networks Based on Voronoi Tessellation. *Journal of Visual Languages and Computing*, 44:106–119, 2018.

Properly drawing clustered networks significantly improves the visual readability of the meaningful structures hidden behind the associated abstract relationships. Nonetheless, we often degrade the visual quality of such clustered

graphs when we try to annotate the network nodes with text labels due to their unwanted mutual overlap. In this paper, we present an approach for aesthetically sparing labeling space around nodes of clustered networks by introducing a space partitioning technique. The key idea of our approach is to adaptively blend an aesthetic network layout based on conventional criteria with that obtained through centroidal Voronoi tessellation. Our technical contribution lies in choosing a specific distance metric in order to respect the aspect ratios of rectangular labels, together with a new scheme for adaptively exploring the proper balance between the two network layouts around each node. Centrality-based clustering is also incorporated into our approach in order to elucidate the underlying hierarchical structure embedded in the given network data, which also allows for the manual design of its overall layout according to visual requirements and preferences. The accompanying experimental results demonstrate that our approach can effectively mitigate visual clutter caused by the label overlaps in several important types of networks.

Refereed proceedings of an academic conference

[fayolle-305-013-02:2017] Pierre-Alain Fayolle, Oleg Fryazinov, and Alexander Pasko. Rounding, Filleting and Smoothing of Implicit Surfaces. In *Proceedings of CAD17*, pages 278–282, 2017.

Modern developments in geometric modelling allow for using a variety of geometry representations in a wide range of applications. As new representations are introduced, one wants to adapt existing processing techniques and methods used with the other representations. One example of such techniques is filleting. It is well known how to perform rounding and filleting for parametric representations, but there is limited prior work for implicit surfaces and procedural volumetric objects. In this work, we discuss possible implementations of filleting, rounding and smoothing operations applied to objects defined in an implicit form by zero level-sets of continuous scalar fields (usually called implicit surfaces). This representation is useful to define a wide range of primitives and operations, including complex geometry such as procedural microstructures. It is possible to simply define these operations, if the scalar field corresponds to the distance to the surface of the object of interest. In practice, however, the distance property can be obtained analytically only for a very limited set of primitives and operations and is easily lost by some common operations in shape modelling, such as,

for example, non-uniform scaling. In this work, we propose to use a numerical method to compute a signed distance field on the basis of an arbitrary continuous scalar field.

[nisidate-305-013-02:2017] Y. Nishidate and I. Khmyrova. Numerical Modeling of the Impact of Top Designed Electrode on LED's Output Performance. In *4th International Conference on Simulation and Modeling Methodologies, Technologies and Applications (SMTA 2017)*, page 033, Sapporo, Japan, Dec. 29–30 2017.

Light-emitting diodes (LEDs) with mesh-like design of top metal electrode with mesh strips of rectangular crossection are studied. Light emission in the LED's active region is assumed to be isotropic. The developed numerical model takes into account light reflection from the bottom electrode. Three-dimensional Laplace equation for electric potential is solved by finite element method. The numerical model incorporates mapped infinite element to account for potential decay far away from the LED structure and finite element model developed for boundary condition at semiconductor-air interface in the mesh opening. Modeling revealed an expected saturation of the total output optical power at very large mesh pitches at. It is also pointed out that the interplay between increasing potential values and reduced mesh openings should be taken into consideration in design of the mesh-like patterned electrodes.

[nisidate-305-013-03:2017] Y. Nishidate and I. Khmyrova. Numerical Procedure for Modeling of Light Emitting Diode with Mesh-Like Electrode. In *6th International Conference on Mathematical Modeling in Physical Sciences (IC-MSQUARE)*, pages Session 1.1–4, Pafos, Cyprus, Aug. 28–31 2017.

A computational procedure is presented for numerical modeling of the light emitting diode (LED) with top p-electrode designed as a mesh with the strips of rectangular cross section. Isotropic light emission in the LED's active region and light reflection from the bottom electrode are considered. Three-dimensional Laplace equation for electric potential is solved by finite element method. The numerical model incorporates mapped infinite element to account for potential decay far away from the LED structure and finite element model developed for boundary condition at semiconductor-air interface in the mesh opening. Simulation results demonstrate the effect of the mesh's geometrical parameters on the total output power.

[nisidate-305-013-04:2017] Y. Nishidate, I. Khmyrova, Yu. Kholopova, E. Polushkin, A. Kovalchuk, V. Zemlyakov, and S. Shapoval. Modeling of InGaN/GaN Light-Emmitting Diodes with Designed p-Electrode. In *41st Workshop on Compound Semiconductor Devices and Integrated Circuits held in Europe (WOCSDICE2017)*, pages 87–88, Las Palmas de Gran Canaria, Spain, May. 21-24 2017.

Light-emitting diodes (LEDs) with InGaN/GaN quantum wells and mesh-like designed top metal electrode are studied. Isotropic light emission in the LED's active region and light reflection from the bottom electrode are considered. Threedimensional Laplace equation for electric potential is solved by finite element method. The numerical model incorporates mapped infinite element to account for potential decay far away from the LED structure and finite element model developed for boundary condition at semiconductor-air interface in the mesh opening. Simulation results demonstrate the effect of the mesh geometrical parameters on the total output power.

[nisidate-305-013-05:2017] I. Khmyrova, Y. Nishidate, J. Kholopova, E. Polushkin, V. Zemlyakov, and S. Shapoval. Modeling of Light-emitting Diode with Mesh-like Top Electrode: Finite-radius Wire Approximation against Mesh Strips with Rectangular Crossection. In *Progress In Electromagnetics Research Symposium (PIERS2017)*, pages 87–88, St Petersburg, Russia, May. 22-25 2017.

In this paper we present results of computer modeling of the LED with mesh-like top electrode based on FEM-model for solution of three-dimensional Laplace equation and numerical procedure developed for modeling of light extraction via the mesh openings.

[shigeo-305-013-02:2017] H.-Y Wu, S. Takahashi, S.-H. Poon, and M. Arikawa. Introducing Leader Lines into Scale-Aware Consistent Labeling. In Editor M. P. Peterson, editor, *Advances in Cartography and GIScience: Selections from the International Cartographic Conference 2017*, pages 21–40. ICA, Springer, 2017.

Consistently placing annotation labels across map scales often poses a problem due to the restriction of the screen space. This problem becomes further exacerbated when we navigate by arbitrarily zooming in and out of digital maps on mobile devices. In this paper, we introduce leader lines to conventional techniques for scale-aware consistent labeling to accommodate more annotation labels on the map domain while retaining their plausible arrange-

ment. The overall visibility of annotation labels is optimized using genetic algorithms while avoiding their unwanted popping effects and sudden leaps regardless of the change in the map scale. The feasibility of the proposed approach is demonstrated by experimental results including comparison with relevant techniques.

[shigeo-305-013-03:2017] H.-Y. Wu, S. Takahashi, S.-H. Poon, and Masatoshi Arikawa. Scale-Adaptive Placement of Hierarchical Map Labels. In B. Kozlikova, T. Schreck, and Editors T. Wischgoll, editors, *Short Paper Proceedings of the 19th Eurographics Conference on Visualization (EuroVis2017)*, pages 1–5. The Eurographics Association, 2017.

Nowadays, digital map services provide a large amount of spatial data and thus facilitate users to dynamically navigate map contents across multiple scales on small mobile devices. In this context, consistently placing map labels in interactive navigation is important but still technically challenging, especially when the labels are associated with multiple layers, which are inherent in map contents. In this paper, we introduce a genetic-based approach to optimize the placement of annotation labels with different ranges of map scales by maximizing label visibility of the existing scale while avoiding unwanted mutual overlaps and sudden popping effects. This is accomplished by grouping the label IDs into multiple chromosomes according to their importance and then forming composite chromosomes, each of which is reordered to optimize the overall visibility of the labels. Our formulation also allows the individual labels to move across the scale adaptively in order to further improve label placement on the respective scales. We show several experimental results to present the effectiveness of the proposed approach.

[shigeo-305-013-04:2017] H.-Y. Wu, Y. Niibe, K. Watanabe, S. Takahashi, M. Uemura, and I. Fujishiro. Making Many-to-Many Parallel Coordinate Plots Scalable by Asymmetric Biclustering. In *Notes Proceedings of the 10th IEEE Pacific Visualization Symposium (PacificVis2017)*, pages 305–309, 2017.

Datasets obtained through recently advanced measurement techniques tend to possess a large number of dimensions. This leads to explosively increasing computation costs for analyzing such datasets, thus making formulation and verification of scientific hypotheses very difficult. Therefore, an efficient approach to identifying feature subspaces of target datasets, that is, the subspaces of dimension variables or subsets of the data samples, is required to describe the essence hidden in the original dataset. This paper proposes

a visual data mining framework for supporting semiautomatic data analysis that builds upon asymmetric biclustering to explore highly correlated feature subspaces. For this purpose, a variant of parallel coordinate plots, many-to-many parallel coordinate plots, is extended to visually assist appropriate selections of feature subspaces as well as to avoid intrinsic visual clutter. In this framework, biclustering is applied to dimension variables and data samples of the dataset simultaneously and asymmetrically. A set of variable axes are projected to a single composite axis while data samples between two consecutive variable axes are bundled using polygonal strips. This makes the visualization method scalable and enables it to play a key role in the framework. The effectiveness of the proposed framework has been empirically proven, and it is remarkably useful for many-to-many parallel coordinate plots.

Writing a part of textbook or technical book

[fayolle-305-013-03:2017] Alexander Belyaev and Pierre-Alain Fayolle. *Generalized Barycentric Coordinates in Computer Graphics and Computational Mechanics*, chapter 3 - Transfinite Barycentric Coordinates. CRC Press, 2017.

Research grants from scientific research funds and public organizations

[shigeo-305-013-05:2017] Shigeo Takahashi (as the Principal Investigator). Ministry of Education Scientific Research Fund (Scientific Research (B)): Dynamic layout optimization for annotated information visualization, 2016–2018.

[shigeo-305-013-06:2017] Shigeo Takahashi (as a Co-Investigator). Ministry of Education Scientific Research Fund (Scientific Research on Innovative Areas) Consolidation of Visualization Platform Toward Facilitating Sparse Modeling, 2013–2017.

Academic society activities

Summary of Achievement

[fayolle-305-013-04:2017] Pierre-Alain Fayolle, 2017.

GRAPP17 - Program committee member

[fayolle-305-013-05:2017] Pierre-Alain Fayolle, 2018.

GRAPP18 - Program committee member

[fayolle-305-013-06:2017] Pierre-Alain Fayolle, 2017.

CAD - Computer Aided Design, reviewer

[fayolle-305-013-07:2017] Pierre-Alain Fayolle, 2018.

CAD - Computer Aided Design, reviewer

[fayolle-305-013-08:2017] Pierre-Alain Fayolle, 2017.

CGI17 - Computer Graphics International, reviewer

[fayolle-305-013-09:2017] Pierre-Alain Fayolle, 2017.

GRAPP17 - International Conference on Computer Graphics, Theory and Applications, reviewer

[fayolle-305-013-10:2017] Pierre-Alain Fayolle, 2018.

GRAPP18 - International Conference on Computer Graphics, Theory and Applications, reviewer

[fayolle-305-013-11:2017] Pierre-Alain Fayolle, 2017.

IJIG - International Journal of Images and Graphics, reviewer

[fayolle-305-013-12:2017] Pierre-Alain Fayolle, 2017.

JVLC - Journal of Visual Language and Computing, reviewer

[fayolle-305-013-13:2017] Pierre-Alain Fayolle, 2017.

TVC - The Visual Computer, reviewer

[fayolle-305-013-14:2017] Pierre-Alain Fayolle, 2017.

JOVI - Journal of Visualization, 2017

[fayolle-305-013-15:2017] Pierre-Alain Fayolle, 2018.

TOG - Transactions on Graphics, reviewer

[nisidate-305-013-06:2017] Y. Nishidate, Sep. 2017.

Reviewer, Applied Optics

[shigeo-305-013-07:2017] Shigeo Takahashi, 2016–.

Associate Editor, International Journal: Computer Graphics Forum

[shigeo-305-013-08:2017] Shigeo Takahashi, 2015–.

Associate Editor: International Journal: Computational Visual Media

[shigeo-305-013-09:2017] Shigeo Takahashi, June 2017.

Programme Co-Chair of the STAR track of the 19th EG/VGTC International Conference on Visualization (EuroVis 2017)

[shigeo-305-013-10:2017] Shigeo Takahashi, August 2017.

Conference Co-Chair, The Symposium on Visual Information Communication and Interaction (VINCI2017)

Advisor for undergraduate research and graduate research

[fayolle-305-013-16:2017] Riki Iwanabe. Web-based 3D Kanji creation, The University of Aizu, 2018.

BSc. dissertation

[fayolle-305-013-17:2017] Yuji Yoshida. Web-based 3D object control via head tracking, The University of Aizu, 2018.

BSc. dissertation

[fayolle-305-013-18:2017] Shogo Suzuki. Web-based implicit surface modeler, The University of Aizu, 2018.

BSc. dissertation

[fayolle-305-013-19:2017] Tomohiko Nagahisa. User-assisted reverse modeling, The University of Aizu, 2018.

BSc. dissertation

[fayolle-305-013-20:2017] Ryota Mukai. Implementation of an implicit surface meshing algorithm using functional programming, The University of Aizu, 2018.

BSc. dissertation

[fayolle-305-013-21:2017] Hokuto Yamaguchi. Multiple offsetting of implicit surfaces, The University of Aizu, 2018.

BSc. dissertation

[fayolle-305-013-22:2017] Shingo Ito. Reverse CSG construction of implicit surfaces and applications, The University of Aizu, 2018.

MSc. dissertation

[nisidate-305-013-07:2017] Yuichi Nakata. Graduation thesis, University of Aizu, 2018.

Thesis Advisor: Y. Nishidate

[nisidate-305-013-08:2017] Kei Kato. Graduation thesis, University of Aizu, 2018.

Thesis Advisor: Y. Nishidate

[nisidate-305-013-09:2017] Takamichi Suzuki. Graduation thesis, University of Aizu, 2018.

Thesis Advisor: Y. Nishidate

[nisidate-305-013-10:2017] Kohei Higuchi. Graduation thesis, University of Aizu, 2018.

Thesis Advisor: Y. Nishidate

[nisidate-305-013-11:2017] Megumi Takato. Graduation thesis, University of Aizu, 2018.

Thesis Advisor: Y. Nishidate

[nisidate-305-013-12:2017] Yuji Tamakawa. Graduation thesis, University of Aizu, 2018.

Thesis Advisor: Y. Nishidate

[shigeo-305-013-11:2017] Takahiro Higuchi. Graduation Thesis: Evaluation Study on Contour-Based Depth Enhancement of 3D Objects, University of Aizu, February 2018.

Thesis Advisor: Shigeo Takahashi

[shigeo-305-013-12:2017] Yuka Yoshida. Graduation Thesis: Interactive Design of Schematic Patterns in Railway Maps, University of Aizu, February 2018.

Thesis Advisor: Shigeo Takahashi

[shigeo-305-013-13:2017] Ken Maruyama. Graduation Thesis: Improved Foldability of 3D Meshes by Optimizing the Order of Edge Cuts, University of Aizu, February 2018.

Thesis Advisor: Shigeo Takahashi

Others

[fayolle-305-013-23:2017] CPFD - Committee for the Promotion of Faculty Development, committee member

Contributions related to syllabus preparation

[nisidate-305-013-13:2017] Numerical Analysis (role: Course Coordinator)

[nisidate-305-013-14:2017] Finite Element Modeling and Visualization (role: Master course instructor)

Preparation of course examination to measure comprehension

[shigeo-305-013-14:2017] CG-ARTS cerfification, CG engineering examinzation committee member, CG-ARTS Society

Contribution related to the building or operation of the university computer system

[nisidate-305-013-15:2017] Computer System 2 Replace Working Group (role: Committee Member)

Contribution related to educational planning management

[nisidate-305-013-16:2017] Honors Program Working Group (role: Committee Member)

[shigeo-305-013-15:2017] Member of the University of Aizu Employment Duty Related Invention Deliberation Council

[shigeo-305-013-16:2017] Member of the University of Aizu Cooperative Research, Etc. Acceptance Deliberation Committee

[shigeo-305-013-17:2017] Member of the University of Aizu Mid-Term Plan Working Group

[shigeo-305-013-18:2017] CAIST Advisory Board Member

[shigeo-305-013-19:2017] Coordinatory of IT Field for Undergraduate Courses

Other significant contribution toward university planning, management, or administration

[nisidate-305-013-17:2017] PC-Koshien Programming Section (role: Problem Preparation Committee)

[nisidate-305-013-18:2017] PC-Koshien Programming Section, Preliminaly and Final Contests (role: Judge)

[nisidate-305-013-19:2017] Entrance Exam (role: Problem Proposals, Problem Creation, and Marking)

[nisidate-305-013-20:2017] Entrance Exam by Commendation(role: Problem Proposals, Problem Creation, and Marking)

Contributions related to regional education

[nisidate-305-013-21:2017] Computer Science Summer Camp (role: Executive Committee)

[nisidate-305-013-22:2017] Computer Science Summer Camp (role: Computer Graphics Course Coordinator)

Did you participate in Public Lectures, and/or Open Campus? (Yes or No) If yes, please describe what you did.

[nisidate-305-013-23:2017] organized place to exhibit, recruited students to explain, provided materials to exhibit.

[shigeo-305-013-20:2017] Computer Graphics for Modeling and Visualizing Complexities (Summer and Autumn)