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PREFACE

Preface

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In this issue, we have four regular papers and five selected papers from NASAGEM 2013. The first regular paper deals with GPU-based polygonization and optimization for implicit surfaces by JunjieChen, Xiaogang Jin, and Zhigang Deng. The second paper is entitled Non-blind deblurring of structured images with geometric deformation byXin Zhang, Fuchun Sun, Guangcan Liu, and Yi Ma. The third paper is Visualization of complex functions on Riemann sphere by MiroslavaValíková and Pavel Chalmovianský. The fourth paper entitled Content-aware model resizing with symmetry preservation by Chunxia Xiao, Liqiang Jin, YongweiNie, Renfang Wang, Hanqiu Sun, and Kwan-Liu Ma.

The remaining papers are described in the preface of the NASAGEM section.

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Preface to the five papers from "New Advances in Shape Analysis and Geometric Modeling" Workshop (NASAGEM 2013) at CGI 2013 Conference, June 2013

We highlight here some interesting results of this issue's papers, often resulting from major extensions of the second NASAGEM 2013 workshop papers.

1. *'Differential Geometric Methods for Examining the Dynamics of Slow–Fast Vector Fields' by Gutschke, Vais and Wolter.* This paper is the first systematic study involving computational differential geometry for the investigation of dynamical systems involving slow and fast vector fields with jump phenomena. The slow vector field is typically defined on an implicitly described submanifold of Euclidean space usually of high co-dimension. Examples of this include modeling of: heartbeat and nerve impulses, non-linear electrical circuits, stability problems in mechanics, etc. This paper employs a novel combination of homotopy methods and geodesic polar coordinates. This results in developing chart representations and visualizations of the implicit manifold and describing jump and hit sets of dynamic trajectories with the manifold. This paper also introduces a cut locus application as a boundary of an univalent geodesic polar coordinate presentation of the respective manifold. This points out the potential power of geodesic polar coordinates for obtaining numerically a nice almost globally univalent parameterization (map) that may be viewed as a planar chart of the *implicitly* defined manifold M indicating also geometric positions of entities relevant to the dynamical system. Showing the feasibility of the aforementioned numerical coordinate presentation may have a major lasting impact by opening up new avenues for giving access, e.g., to implicit 2- and 3-dimensional (or for a local analysis only even higher dimensional) manifolds of high co-dimension. The latter manifolds, often defined as solutions of non-linear systems of equations, have typically not been properly accessible so far.

2. *'Geodesic Bifurcation on Smooth Surfaces' by Thielhelm, Vais and Wolter.* This paper is a systematic study on the computation of shortest geodesics joining any two points on a surface. Computational geometers dealing with this problem typically approximate the surface by a discrete point set. However, such approach does not allow study of physically relevant phenomena such as focal curves (related to caustics of wave fronts, singularities of dynamical systems and catastrophe theory) and prevents a full understanding of

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cut loci and their relation to the exponential map providing an efficient instrument of describing the surface by geodesic polar coordinates. Classically, a point qis on the cut locus $\mathbf{C}_p$ of point **p** on a surface M, if there is a shortest geodesic from **p** to **q** loosing its minimal length property after extension beyond **q**. By a theorem of Wolter [35], the cut locus $\mathbf{C_p}$ can be described equivalently as the set all points **q**, having at least two shortest geodesics to p including their limit points. This paper studies the subtle behavior of geodesics close to a cusp singularity of the exponential map (or close to a cusp singularity of a focal curve with respect to **p**). This article provides an efficient homotopy method for computing geodesic paths to **p** having their end point **q**, located on geodesics emanating tangentially from the cusp curve. This yields a generalized local inverse of the exponential map near a cusp singularity. Such singularity analysis also allows refined computations of branches of $\mathbf{C_p}$ employing the medial ordinary differential equation system and improving the computation at the singular endpoints of such branches. It finally also gives additional tools for the computation of geodesic Voronoi diagrams on surfaces in the presence of focal curves. Such concepts enrich the analysis and computation of geodesic Voronoi diagrams now by extending them as to include branches of the cut locus of any point $\mathbf{p_i}$ as far as it is contained in the Voronoi cell around $\mathbf{p_i}$.

3. *'Subimage Sensitive Eigenvalue Spectra for Image Comparison' by Berger, Vais and Wolter.* This paper is a novel foundational contribution to approach the very difficult problem of recognition of similar subimages contained in different images. The paper introduces new methods employing analysis of eigenfunctions and eigenvalues of modified Laplace–Beltrami operators. The earliest work on applying Laplace–Beltrami spectra to recognize grey value images appears to be that from the Welfenlab (c. 2001), see review in Ref. [31] of this paper. However, the methods presented in this paper (though involving Laplace spectral invariants as well) must go far beyond those early ideas discussed in Ref. [21], as they attack a much harder problem because the usual Laplace–Beltrami spectrum as well as the Laplace spectrum associated with the "grey value density function" are global invariants of the image. This means they are changing as soon as some changes are made in the image while keeping the subimage fixed. This paper introduces new concepts such as localization densities, co-localization, and co-localization matrices. The localization density of an eigenfunction assigns a non-negative value to essentially every point **x** of the domain where the eigenfunction is defined. This density measures the sensitivity of the respective eigenvalue to perturbations of the underlying differential operator in the vicinity of **x**. The co-localization of two eigenfunctions measures to what extent two eigenfunctions are localized on the same subdomain. This yields a co-localization matrix assigning to each pair of eigenfunctions a number measuring their normalized overlap. This paper discusses using such co-localization matrix to discover similar subimages within a larger image.

4. *'Interactive Partial 3D Shape Matching with Geometric Distance Optimization' by Martinek, Grosso and Greiner.* This paper deals with the important problem of developing fast and reliable methods for minimizing the geometric distance between some source and some geometric target set. A practical application is optimal matching of a subset of a manufactured object to an appropriate subset of a larger design object, a fundamental problem in precision quality control for manufacturing. Here, a manufactured object described by laser scanner data fits into an envelope surface enclosing the idealized design object possibly presented by spline surfaces. For an early contribution to this topic, see reference [39], also a reference in the paper by Berger *et al* in this issue. Such reference is no coincidence as recognition of partial images can be understood as a partial shape-matching problem as well. For dealing with the problem presented in this paper, the authors have a track record where they have been consistently developing and improving an approach combining feature identification tools measuring together with rapid distance offset computations (around the target set) supported by GPU-based parallel computations. The latter computations provide a colored 3D look-up table, separating the offset space around the target object in a few different regions (discrete layers) distinguished by their respective distance to the target object. The feature classification method chosen by the authors of this paper employs a normalized deviation of the surface normal vector from the surface normal at a reference point.

5. *'Triangular Mesh Simplification of the GPU' by Papageorgiou and Platis.* This paper contributes to the important rapidly growing field of GPU-based parallelization techniques in geometric modeling. In fact, this paper contributes to a crucial problem in modern geometric modeling, mesh simplification. Despite the ongoing rapid increase in primary memory and computation power, the number of meshes that can be handled efficiently during geometry processing and especially in FEM computations is still small. Traditionally, mesh simplification algorithms were mostly designed for implementation in computers with classical CPU architecture. The main merit of this paper is that it designs a mesh simplification algorithm that fully exploits the advantages of modern graphics processors. A specific feature in this article is that it provides appropriate methods to find independent areas where edge-collapsing operations will not affect simplifying operations in other areas. For this purpose, the authors

employ a concept that defines for central vertices of (independent) areas a property called super independence. The latter property is based on respective distance properties of the aforementioned central vertices defined via distances on the graph representing the mesh. This can then be efficiently used and computed in parallel to find a maximal independent set on the graph mesh representation.

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