

0.0.1 Report of project part 1

Title: Coordination and Service, Knowledge transfer and sustainability

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This subproject consists of two parts. The first one, Coordination and Service, was applied for as Subproject 01. The second one, Knowledge transfer and sustainability, was applied for as Subproject 08. Following the suggestion of the referees, both subprojects were merged into a single one. The first part has mainly been dealt with by the Linz group, while the second part was performed mainly by the group at Vienna.

Summary

This subproject focused on the communication and exchange of ideas and knowledge within the research network. In order to facilitate these scientific exchanges, we organized a series of internal seminars and international workshops, and we run the project website.

At the internal seminars, talks about the ongoing research activities were presented by the collaborators in this research network. In addition, the team of this subproject has prepared tutorials about fundamental aspects of the various fields of expertise which are present in this network. The aim of this activity was to transfer knowledge between the different research groups within the network.

A major goal has been to collect and continue these themes in a textbook on Industrial Geometry. Additionally a novel textbook on *geometry for architecture* has been supported. It covers fundamental and classical material and proceeds to advanced and modern topics in geometry which are close to present research topics in geometric optimization and discrete differential geometry.

Report and Activities

Additional funding for computer equipment In a coordinated application to the Infra III Programme of the Austrian Federal government, the partners in the NRN applied for funding for computer (and other) equipment. The application was successful, and all partners were able to acquire the computer equipment which was needed for the project. Without this additional funding, it would have been impossible to obtain the results presented in this report.

Status seminars In order to facilitate the scientific exchange between the participating groups, we organized a sequence of status seminars. The investigators and collaborators of the network participated in these events.

- The kick-off meeting took place in Obergurgl in April 2005. At this event, the project partners mainly presented their field of work to the other partners.
- The first status seminar was held as a 3-day workshop in Graz/St. Martin, in November 2005. The programme of this event consisted of 3 different components:
 - scientific talks of the collaborators in the NRN, who reported about ongoing research and recent results,
 - a tutorial session on Computer Aided Geometric Design and its geometric foundations, and
 - a one-day intensive course on the CGAL library, which was taught by Monique Teillaud (INRIA, France).
- The second status seminar took place at Strobl in June 2006 (4 days). The programme combined two parts:
 - The collaborators and investigators of the NRN presented their recent results, focusing mainly on interactions between the participating groups. 15 talks were presented.
 - A tutorial on Computational Geometry was provided, in order to stimulate the transfer of knowledge.

In addition, the program left ample space for individual discussions and project seminars, which was used intensively.

- The third status seminar was held as a 2-day extension of the international workshop on Level Set methods and Image Processing. It took place in Obergurgl in September 2006. It was open also for the participants in this workshop. We used this opportunity to present results of the ongoing research within the network to these external participants. In addition, a tutorial on Image Processing has been presented.
- The fourth status seminar took place during 2 days in March 2007, and was held at St. Martin (Graz). It served 3 main purposes.
 - Cooperation between the participating groups, in particular reporting about the ongoing research activities.
 - Continuation of the knowledge transfer, by presenting a tutorial on Discrete Differential Geometry and applications in architecture.
 - Planning of the proposal for the second funding period.

The date and location was aligned with the 23rd European Workshop on Computational Geometry 2007.

- A fifth status seminar has been scheduled for March 2008. It will again be held at Strobl. We expect that this event will serve as the kick-off meeting for the continuation of the network activities.

Additional information concerning these events is provided in Section 1.3.1.2.

International workshops We organized several workshops for participants from all over the world. These workshops were dedicated to special topics which are under investigation within the NRN.

- A five-day international workshop on “Variational, PDE, and Level Set Methods”, which was mainly organized by the Innsbruck group, took place in Obergurgl in September 2006. Several of the invited papers will appear shortly in a special issue of Computing.
- A workshop focusing on the interaction of Geometric Modeling and Computational Geometry, which was jointly organized by the groups in Linz and Graz, was held in the monastery Stift Vorau, in November 2006. In addition to 8 lectures by invited speakers (including a representative of Boeing Inc.), several talks of participants in this network were given.
- A workshop on “Computational Methods for Algebraic Spline Surfaces” has jointly been organized by B. Jüttler (Linz), M. Peternell (Vienna) and J. Schicho (Linz). This workshop took place in the second week of September 2007 at Strobl.
- Immediately after this event, a workshop on “Polyhedral Surfaces and Industrial Applications” took place at Strobl. It has jointly been organized by A. Bobenko (Berlin), K. Polthier (Berlin), H. Pottmann (Vienna) and J. Wallner (Graz).

Additional information concerning these events, including the lists of the invited speakers, is provided in Section 1.3.1.1.

Web Site and Technical Report Series As another major activity in this subproject, we set up the web-site www.industrial-geometry.at. It contains information about the partners and projects, about recent publications and about the past and future meetings. For instance, many of the talks presented at status seminars and international workshops are available in electronic form.

A series of NRN reports (preprint series) has been established. These reports can be submitted and accessed via the homepage. As of September 2007, 56 reports have been posted at this web site.

In addition, the web site includes a database of scientific publications of the project partners.

Tutorials – Knowledge transfer Fundamental material for lectures from classical geometry, curves and surfaces in CAGD, Computational Geometry and geometric optimization has been collected. Part of them have been presented at introductory lectures at the status seminars. These short courses aim at transferring knowledge between the different research groups within the research network and help the researchers to get to know methods and techniques from the various fields of science coming together in Industrial Geometry.

More precisely, 4 tutorials were developed and presented at the four status seminars:

1. Classical geometry on curves and surfaces in CAGD [P1-C08, P1-C09, P1-C10],
2. Fundamentals of Computational Geometry [P1-C11, P1-C12, P1-C13],
3. Image processing [P1-C14, P1-C15], and
4. Discrete differential geometry [P1-C17, P1-C18].

Each of them was jointly prepared by the team of Subproject 01 and one of the participating groups in the NRN (Linz, Graz, Innsbruck and Vienna, respectively).

These introductory lectures were considered as the best possibility to distribute the various knowledge present at the different research groups to all participating researchers. Most of the short course materials, which includes several matlab and CGAL demo programs for free form curves and surfaces and Computational Geometry tasks, are available at the homepage of the research network.

Case studies and comparison of methods Distance functions of objects in Euclidean spaces as well as in spaces with local Riemannian metrics are of great interest for many applications. Since the exact evaluation of distance functions can be quite costly, good approximations are needed. The concept of chamfering applies not only to Euclidean spaces but can be used in Riemannian geometries as well, where the masks are obviously depending on the locus.

A further topic which has been addressed has been the approximation of objects by a family of spheres in collaboration with Subproject 05, see [P1-B03] and the computation of convolution surfaces and Minkowski sums of objects. This has several applications in computer graphics as well as in robotics. The first method aims not only at this approximation task but the centers of the spheres are good sampling of the medial axis of the object. The second method described in [P1-J02] is a quite efficient method for approximate computation of Minkowski sums. This extends the computation of swept volumes [P1-J01] as envelopes of objects with respect to one-parametric motions to two-parametric translational motions.

Compilation of lecture notes and textbooks In the first two years of the funding period, major effort was dedicated to compile lecture notes for a course entitled *Industrial Geometry*, already being taught at the TU Vienna. Test implementations for registration

algorithms with and without known correspondences have been performed. A further topic has been the reconstruction of developable surfaces from point clouds. Two diploma theses have been supervised, one by M. Forstner on the reconstruction of developable surfaces from point clouds, and the second by B. Stöfler on registration and data filtering for an industrial application concerning car reflectors, see table ???. The latter is strictly confidential since it has been supported by the company ZKW.

Most work of the last year is dedicated to support the finalization of a novel textbook on geometry and its applications in architecture, [P1-M01]. The content of this monograph reaches from a fundamental introduction to advanced methods and current research topics, mainly in discrete differential geometry. Figures for the introductory part and test implementations for the advanced topics have been provided.

Monographs

[P1-M01] H. Pottmann, A. Asperl, M. Hofer, and A. Kilian (to appear). *Architectural Geometry*. Bentley Institute Press.

Journal articles

- [P1-J01] M. Peternell, H. Pottmann, T. Steiner, and H. Zhao. Swept volumes. *Computer-Aided Design Appl.*, 2:599–608, 2005.
- [P1-J02] M. Peternell and T. Steiner. Minkowski sum boundary surfaces of 3D-objects. *Graphical Models*, 69:180–190, 2007.
- [P1-J03] M. L. Sampoli, M. Peternell, and B. Jüttler. Rational surfaces with linear normals and their convolutions with rational surfaces. *Comput. Aided Geom. Design*, 23:179–192, 2006.
- [P1-J04] M. Peternell and B. Odehnal. Convolution surfaces of quadratic triangular Bézier surfaces. *Computer Aided Geometric Design*, 2007. to appear.

Refereed articles in books and conference proceedings

- [P1-B01] M. Peternell and T. Steiner. A geometric idea to solve the eikonal equation. In B. Jüttler, editor, *SCCG '05: Proceedings of the 21st spring conference on Computer graphics*, pages 43–48. ACM Press, 2005, ISBN 1-59593-203-6.
- [P1-B02] M. Peternell. Sphere-geometric aspects of bisector surfaces. In *Algebraic Geometry and Geometric Modeling*, pages 107–112, 2006. Proceedings of the conference in Barcelona, September 4-7.
- [P1-B03] Aichholzer, O., Aurenhammer, F., Hackl, T., Kornberger, B., Peternell, M., and Pottmann, H. (2007). Approximating boundary-triangulated objects with balls. In *Proc. 23rd European Workshop on Computational Geometry*, pages 130–133. TU Graz.

Invited talks

[P1-I01] M. Peternell. Rational Offset Surfaces and Related Problems. Conference on Automated Deduction in Geometry, Pontevedra (Spain), 2006.

Contributed talks and poster presentations

- [P1-C01] M. Peternell. A geometric idea to solve the eikonal equation. Spring conference on computer graphics, Budmerice (Slovakia), 2005.
- [P1-C02] M. Peternell. Constrained Surface Approximation from a Geometric Optimization Perspective. SIAM Conference on Geometric Design and Computing, Mesa, (Arizona, USA), 2005.
- [P1-C03] M. Peternell. Envelopes of Moving Solids. SIAM Conference on Geometric Design and Computing, Mesa (Arizona, USA), 2005.
- [P1-C04] M. Peternell. Boundary Surfaces of Moving Objects. Workshop on Industry Challenges in Geometric Modeling and CAD, Darmstadt (Germany), 2006.
- [P1-C05] M. Peternell. Boundary Surfaces of Moving Objects. Conference on Curves and Surfaces, Avignon (France), 2006.
- [P1-C06] M. Peternell. Sphere-geometric aspects of bisector surfaces. Algebraic Geometry and Geometric Modeling, Barcelona (Spain), 2006.
- [P1-C07] M. Peternell. Convolution surfaces of quadratic triangular Bézier surfaces. Workshop on Non-Linear Computational Geometry, Minneapolis (Minnesota, USA), 2007.
- [P1-C08] B. Jüttler. Basic Geometry for CAGD. 1st FSP meeting, Graz, 2005.
- [P1-C09] M. Peternell. Curves for CAGD, 1st FSP meeting, Graz, 2005.
- [P1-C10] T. Steiner. Surfaces for CAGD, 1st FSP meeting, Graz, 2005.
- [P1-C11] O. Aichholzer. Introduction to computational geometry, Strobl, 2006.
- [P1-C12] T. Hackl. Triangulations and related structures, Strobl, 2006.
- [P1-C13] T. Steiner. Algorithms for 3D and higher dimensions, Strobl, 2006.
- [P1-C14] K. Frick. PDE's and Image Processing 1, Obergurgl, 2006.

- [P1-C15] M. Grasmair: PDE's and Image Processing 2, Obergurgl, 2006.
- [P1-C16] T. Steiner. Elementary differential geometry of curves and surfaces, Obergurgl, 2006.
- [P1-C17] H. Pottmann. Discrete differential geometry 1, Graz 2007.
- [P1-C18] J. Wallner. Discrete differential geometry 2, Graz 2007.

Additional references