# Preface

*Geometry* is one of the oldest systemized subdisciplines of mathematics. Due to the growing capabilities of computers, algorithmic approaches assume an increasingly significant role within geometry. Against this background, we understand *computational geometry* in a very broad sense as that part of geometry which is (in principle) algorithmically accessible.

The purpose of this book is to provide a functional access to computational aspects of geometry, based on a broad mathematical foundation. Let us point out that the current text is intended to be introductory. Thus restrictions are inevitable, and the choice of topics is naturally biased by the preferences of the authors.

The first part of the book deals with concepts and techniques which refer to polyhedral (i.e., linearly confined) structures. Its mathematical roots lie in discrete and convex geometry. Our treatment includes algorithms for computing convex hulls as well as the construction of Voronoi diagrams and Delone triangulations. The second part is an introduction to some primary concepts in non-linear computational geometry and develops the relevant techniques from computational algebraic geometry. Here, we focus on Gröbner bases and on solving systems of polynomial equations. The third part of the book is devoted to some selected applications in computer graphics, curve reconstruction and robotics.

A prior concern of the book is to establish interconnections between computational-geometric phenomena and other subdisciplines of mathematics (such as algebraic geometry, optimization and numerical mathematics). To achieve this goal we concentrate on some essential ideas and methods. Moreover, the book offers some insights into the possibilities of current computer software (such as `polymake`, `Maple`, or `Singular`) in this context.

## Audience and Required Background

The book is directed towards advanced undergraduates and beginning graduates in mathematics and computer science, as well as towards engineering students who are

interested in applications of computational geometry (such as in robotics). The book only assumes common concepts from undergraduate courses in linear algebra and calculus. Additional knowledge in discrete mathematics, optimization, algorithms and algebra is useful, however, the material needed from these areas is developed in the text or—in some cases—collected in appendices.

## Aim of the Book

It is not intended to cover all the aspects comprehensively. Instead—starting from computational questions in several current topics in geometry—various entry points to more specialized literature and research directions shall be offered.

In contrast to books on computational geometry which originate from computer science, the aspect of abstract data types (which is often important for efficient implementations) is covered only marginally.

## History and Acknowledgments

The present book is a revised and updated translation of the German textbook *Algorithmische Geometrie: Polyedrische und algebraische Methoden*, Vieweg, 2008.

The original version resulted from the authors' courses at Technische Universität Berlin, Technische Universität Darmstadt, and Goethe-Universität Frankfurt am Main. The participants of these courses have provided many stimulating discussions and suggestions.

Some of the pictures are courtesy of Sven Herrmann (Fig. 13.3) and Nikolaus Witte (Fig. 1.1).

The translation has been prepared by Theresa Szczepanski and the authors.

The German version benefited from comments and criticism by René Brandenberg, Peter Gritzmann, Martin Henk, Sven Herrmann, Katja Kulas, Alexander Martin, Werner Nickel, Marc Pfetsch, Cordian Riener, Thilo Rörig, Moritz Schmitt, Achill Schürmann, Dieter Schuster, Reinhard Steffens, Natascha Theobald, Tanja Treffinger, Axel Werner, Claudia Wessling, Nikolaus Witte, Ronald Wotzlaw, and Günter M. Ziegler. Further comments by Benjamin Assarf, Roberto Henschel, Katrin Herr, Sadik Iliman, Kai Kellner, Werner Seiler, Christian Trabandt and Timo de Wolff were very helpful when preparing this version.

We are very grateful to everybody for their contributions.

Darmstadt, Germany — Michael Joswig
Frankfurt am Main, Germany — Thorsten Theobald

http://www.springer.com/978-1-4471-4816-6

Polyhedral and Algebraic Methods in Computational Geometry

Joswig, M.; Theobald, T.

2013, X, 250 p. 67 illus., 17 illus. in color., Softcover
ISBN: 978-1-4471-4816-6