Geometric Functions in Computer Aided Geometric Design

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Aphrodite's mesh was ray-traced using a simulated screen shaped into a helicoid tape embedded in a 3D ellipsoid. Prof. Dr. Eng. Oscar Ruiz and undergraduate assistants Carlos Vanegas and Ricardo Serrano. CAD CAM CAE Laboratory, EAFIT University, 2006-2007.

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Contents

Chapter 1

Introduction

There are plenty of books that treat the topic of Computer Aided Geometric Design and Applications. These books usually have either one of two extreme approaches: purely operative and purely mathematical. The present book intends to fill this gap, by discussing important underlying mathematical facts and terminology of Computer Aided Geometric Design, while at the same time giving the reader a direct insight in the practical consequences of such facts and terms.

The overall content of the undergraduate courses Introduction to CAD CAM Systems, Introduction to Computer Aided Geometric Design or equivalent spans (i) Geometric Transformations, (ii) Parametric Curves and Surfaces, and (iii) Geometric and Solid Modeling. The present book deals with Geometric Transformations. The authors found that a previous material by them ([Rui05]) presents the three topics in a very practical manner, leaving aside mathematical foundations that may be useful for the educated CAGD developer. The present book intends to represent such a deeper view, in the specific realm of Geometric Transformations.

The term Geometric *Transformations* is widely used in the practice of Computer Aided Geometric Design and Manufacturing. However, it is, formally, incorrect, since the material covers functions that are not *transformations* in the mathematical sense. They are not bijections. But they are useful, and necessary (an example are projections). The authors do not intend to solve a very ancient terminology issue. Therefore, they simply go along with the term, and write about Geometric Transformations referring to rotations, translations, perspectives, shears, affine, etc.

The material included in these notes corresponds to the lectures of the course IM024, Introduction to CAD CAM Systems, delivered by Profs. Oscar Ruiz and Carlos Cadavid in EAFIT University in the period 1996-2008. The exercises were assigned by Profs. Ruiz and Cadavid, and its solution and documentation supervised by them, as appears in the original manuscripts. At the end of the book a list of undergraduate students is given, who carried out such academic and editorial work under the supervision of Profs. Ruiz and Cadavid.

Chapter 2 explores the basic terminology required, and the concept of (affine) groups. Chapter 3 discusses the effects of the terms just introduced, on the property invariance of transformations. Chapter 4 is devoted to the particular domain of Rigid Transformations, fundamental for kinematics, robotics, dynamic simulations, computer graphics, etc. Chapter 5 deals with non rigid transformations, such as parallel and perspective projections.