

# Preface

This book introduces undergraduate and postgraduate students to mathematics and related computer programming techniques used in Computer Graphics. In a gradual approach, the book exposes students to the underlying mathematical ideas and leads them towards a level of sufficient understanding of detail to be able to implement libraries and programs for 2D and 3D graphics. Through the use of numerous code examples, the students are encouraged to explore and experiment with data structures and computer programs (in the C programming language) and to master the related mathematical techniques.

This book is meant for students with a minimum prerequisite knowledge of mathematics. It assumes very little and any high school graduate should be able to follow this book. The intended reader is expected to have had some basic exposure to topics such as functions, trigonometric functions, elementary geometry and number theory, and elements of set theory. The reader is also expected to have some familiarity with some computer programming language such as C, although any algorithmic language will serve the purpose.

The book includes a simple but effective set of routines, organised as a library, that covers both 2D and 3D graphics. This parallel approach of exposing the students to the mathematical theory and showing them how to incorporate it into example programs is the major strength of this book. It both demystifies the mathematics and it demonstrates its relevance to 2D and 3D computer graphics, thus motivating and rewarding the reader.

This book is organised into ten chapters and four appendices. Chapters 1–4 are characterised as survival kits, as they introduce the basic mathematical concepts and techniques that are applied and are essential for a thorough understanding of the remaining six chapters. The material presented in this book has been used to teach mathematical and programming techniques to both Computer Scientists and Artists. For a Bachelor degree that covers the mathematics for computer graphics over three years, Chapter 1 would normally be taught at the end of year one, Chapters 2–9 would normally be taught in year two of the course and Chapter 10 may be taught at the end of year two or the beginning of year three.

Chapter 1 introduces readers to concepts of set theory and function theory. It assumes no prior knowledge of these topics and it is self-contained.

Chapter 2 deals with vectors and vector algebra. It introduces readers to these topics assuming no prior knowledge save a rudimentary understanding of 2D and 3D geometry and some elements of trigonometry. Once readers have mastered the material presented in this chapter, they will be able to solve complex vector algebra problems and to implement their solutions in computer programs. Appendix 1, which is associated with this chapter, presents an example implementation of a 3D vector-algebra library.

Chapter 3 deals with matrices and matrix algebra. It introduces readers to these topics assuming no prior knowledge of matrices but requiring a good understanding of vector algebra. Once readers have mastered the material presented in this chapter, they will be able to solve complex matrix algebra problems and to implement their solutions in computer programs. Appendix 2, which is associated with this chapter, presents an example implementation of a 4D matrix-algebra library.

Chapter 4 deals with vector spaces, which is one of the most abstract subjects dealt with in this book and thus one of the topics that some students find more difficult. This chapter requires a good understanding of both vector and matrix algebra. It is self-contained and, although it introduces the very important concept of the change of basis matrix, it may be omitted by the uninterested reader.

Chapters 5 and 6 deal with the concepts of 2D transformations and 2D clipping algorithms respectively, and their implementation. Appendix 3, which is associated with these two chapters, presents an example implementation of a comprehensive 2D graphics library.

Chapter 7 deals with the concepts of viewing and projection transformations, 3D clipping, and their implementation. Appendix 4, which is associated with this chapter, presents an example implementation of a comprehensive 3D graphics library.

Chapter 9 examines the data structures required to represent 3D models and some of the hidden-surface removal and rendering techniques used in the creation of computer generated images. This chapter also introduces readers to some of the simple empirical lighting and shading models used in real-time graphics.

Finally, Chapter 10 presents a much more detailed exposition of the nature of light and examines, in some detail, physically-based lighting and shading models, and rendering techniques and algorithms. The material presented in this chapter is more mathematically challenging.

Most of the material presented in this book has been designed to be accessible to B.A., B.Sc., M.A. and M.Sc. students of a computer animation, digital special effects or technical direction degree course. This book however will also be useful to computer science students studying a graphics or animation unit and to technical directors in CGI production.

The vector and matrix notation of this book is designed to appeal to both North American and International readers.

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