SYMBOLIC COMPUTATION

计算机辅助设计 基本原理和系统结构

J. Encarnação
E. G. Schlechtendahl

Computer Aided Design

Fundamentals and System Architectures

Springer-Verlag
Berlin Heidelberg New York Tokyo

J. Encarnação E.G. Schlechtendahl

Computer Aided Design

Fundamentals and System Architectures

With 176 Figures
12 of them in Color

Springer-Verlag
Berlin Heidelberg New York Tokyo
1983

Prof. Dr. José Encarnação
Institut für Informationsverwaltung
und Interaktive Systeme
FB 20 – TH Darmstadt
Alexanderstraße 24
6100 Darmstadt

Dr. Ernst G. Schlechtendahl
Kernforschungszentrum Karlsruhe
Postfach 3640
7500 Karlsruhe

ISBN 3-540-11526-9
Springer-Verlag Berlin Heidelberg New York Tokyo
ISBN 0-387-11526-9
Springer-Verlag New York Heidelberg Berlin Tokyo

Library of Congress Cataloging in Publication Data.
Encarnação, José Luis.
Computer aided design.
(Symbolic computation. Computer graphics)
Includes bibliographies and indexes.
1. Engineering design – Data processing. I. Schlechtendahl, E.G. (Ernst G.), 1938– .
II. Title. III. Series.
TA174.E47 1983 620'.00425'02854 83-528
ISBN 0-387-11526-9 (U.S.)

Printed in Germany

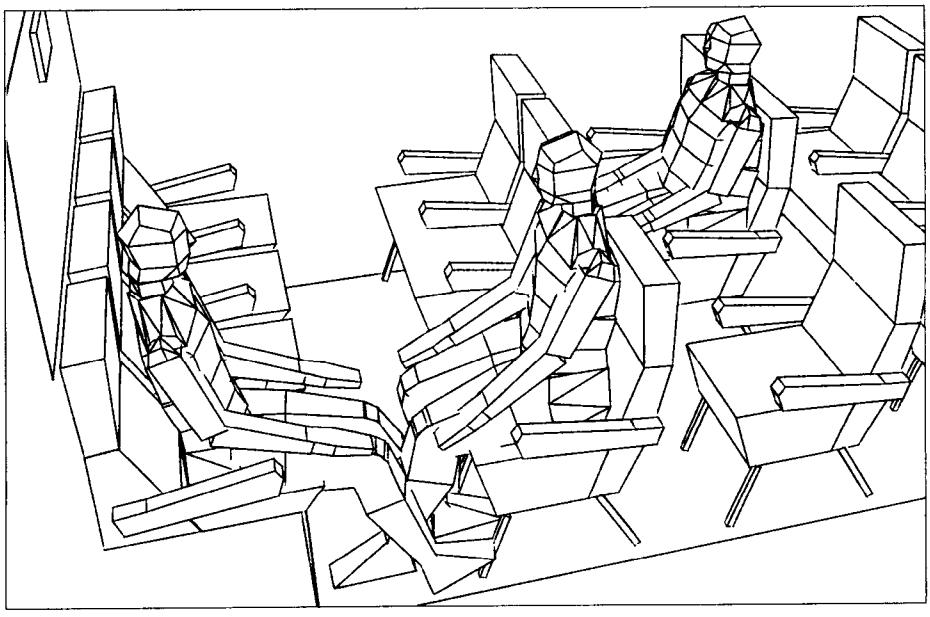
Typesetting, printing, binding: Universitätsdruckerei H. Stürtz AG, Würzburg

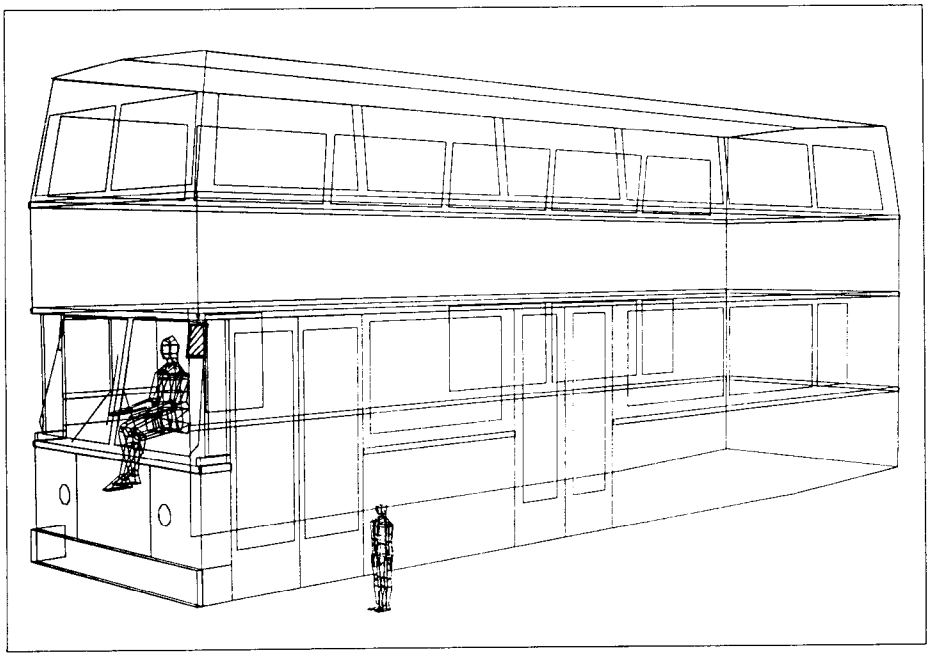
2145/3140-543210

SYMBOLIC COMPUTATION

Contents

1 Introduction





Vehicle design
(courtesy of Compeda Ltd., London, UK)

1.1 Purpose of This Book

The intention of this book is to describe principles, methods and tools that are common to computer applications for design tasks, independent of a particular product. It does not present cookbook recipes on how to select a commercially available CAD system for designing a particular product, or how to write a new CAD system for this purpose. When we consider CAD as a discipline lying somewhere between engineering and computer science, the tendency towards generalization inevitably leads us to emphasize the computer aspects. But the book is primarily for engineers who plan to work in CAD or who already do. They will recognize experiences they may have had, placed in a more general context. They should also find useful ideas which they can put into practice in their own environment. The book is also intended for students who want to give themselves a broader fundamental background in CAD.

1.2 Scope of CAD

The meaning of "computer-aided design" (CAD) has changed several times in its past twenty years or so of history. For some time, CAD was almost synonymous with finite element structural analysis. Later, the emphasis shifted to computer-aided drafting (most commercially available CAD systems are actually drafting systems). Handling smooth surfaces, as required in ship-building and the automobile industry, became another key issue. More recently, CAD has been associated with the design of three-dimensional objects, (this is typical in many branches of mechanical engineering). In this book, we consider CAD as a discipline that provides the required know-how in computer hardware and software, in systems analysis and in engineering methodology for specifying, designing, implementing, introducing and using computer based systems for design purposes.

Computer-aided design is often treated together with computer-aided manufacturing (CAM). We are not including CAM in this book, since CAM starts from data — preferably machine-readable data — that are produced in the design process, but CAM is not part of the design process itself. The same applies to computer-aided testing (CAT), computer-aided work planning (CAP), and computer-aided maintenance. Knowledge about the available manufacturing, testing, and maintenance capabilities certainly influences the design; but the methods applied in these other CA's are not the concern of this book.

Recently the term computer-aided engineering (CAE) has been used for summarizing all computer aids in design, while restricting CAD to computer-aided drafting. Here, however, we will continue to associate the term CAD with the wider meaning defined above.

Design is not only the more-or-less intuitively guided creation of new information by the designer. It also comprises analysis, presentation of results, simu-

lation and optimization. These are essential constituents of the iterative process, leading to a feasible and, one hopes, optimal design.

1.3 Content of the Book

In Chapter 2 we present briefly the *history* of CAD. The main *components* of CAD systems are identified, and their principal functions described. Economical and interdisciplinary aspects are discussed.

Chapter 3 starts with a *systems analysis* of the *design process*. The notion of a process is introduced as a fundamental tool to describe activities like design as a whole, computer-aided design, program executions, terminal sessions etc. The *environment* and the *resources* which the environment must supply for the successful execution of any process are discussed. The problem of *modelling* the design objects in an abstract *schema* and the interrelation between the schema and the planning of the individual step in the design are analysed.

Chapter 4 concentrates on the *interfaces* among the components of a CAD system, including the human operator. The problem of *mapping* an abstract schema onto the capabilities of various programming, command, or data description languages is described in detail. Emphasis is laid upon the *resource* aspect and its influence on the design of CAD systems. The concept of a *CAD software machine* is introduced, and rules for designing such machines are given.

In Chapter 5 we deal with the most important computer science techniques and suitable types of software systems utilized in CAD. Specification techniques, data structures and *data base systems*, man-machine communication and *dialogue techniques*, *graphic kernels* and *system nuclei* are treated in some detail.

Chapter 6 presents selected engineering methods for CAD. Various numerical *analysis* methods (such as finite elements, simulation and optimization) are treated only to the extent that the reader may obtain select entry points into the extensive literature on these subjects. Not the methods themselves but rather their *embedding into CAD* lies within the scope of this book. Graphic techniques for *presentation* of numerical results are described in more detail.

Chapter 7 gives selected *examples* of CAD *applications* taken from industrial practice.

Chapter 8 summarizes the present *trends* in CAD, both with respect to computer hardware and software and with respect to the human and social aspects of CAD.

Color figures from all chapters are collected on pages 341 through 346.

1.4 Summary

The aim of this first chapter was to give the reader an impression of what he may expect to learn from this book. We have also explicitly indicated impor-

tant areas which will not be covered at all, or will be touched on only briefly (computer-aided manufacturing or finite elements, for instance). Readers who prefer to study just one topic or another are invited to jump to the pertinent chapters immediately.

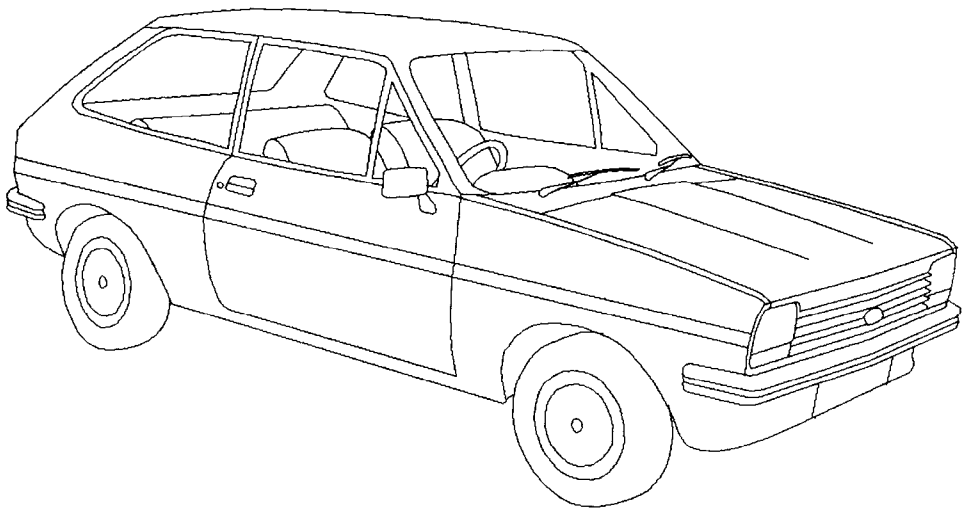
1.5 Acknowledgements

The authors gratefully acknowledge the support of their organizations, Technische Hochschule Darmstadt and Kernforschungszentrum Karlsruhe, which have made their facilities available for the preparation of this book. The laborious work of preparing the illustrations both manually and with computer aids was performed with great care by Frl. Stutz. We are much obliged to Mr. G. Becker who copy-edited the whole manuscript. Finally, we very much appreciate the ideal support we received from many experts in the field, both from Germany and other countries. Communication with them has been an invaluable help in collecting together the great variety of thoughts in the CAD world and presenting them here. We also wish to express our gratitude to our families, who had to spend many weekends without husband and father during the preparation of the manuscript.

1.6 List of Frequently-Used Abbreviations

AI	artificial intelligence
CAD	computer-aided design
CAE	computer-aided engineering
CAM	computer-aided manufacturing
CAP	computer-aided work planning
CAT	computer-aided testing
CODASYL	conference on data system languages
COM	computer output on microfilm or microfiche
DBMS	data base management system
DBTG	data base task group
DC	device coordinates
GKS	graphical kernel system
I/O	input and output
NDC	normalized device coordinates
2-D	two-dimensional
$2\frac{1}{2}$-D	two-and-a-half-dimensional
3-D	three-dimensional

2 History and Basic Components of CAD



Vehicle design
(courtesy of Versatec, Santa Clara, USA)