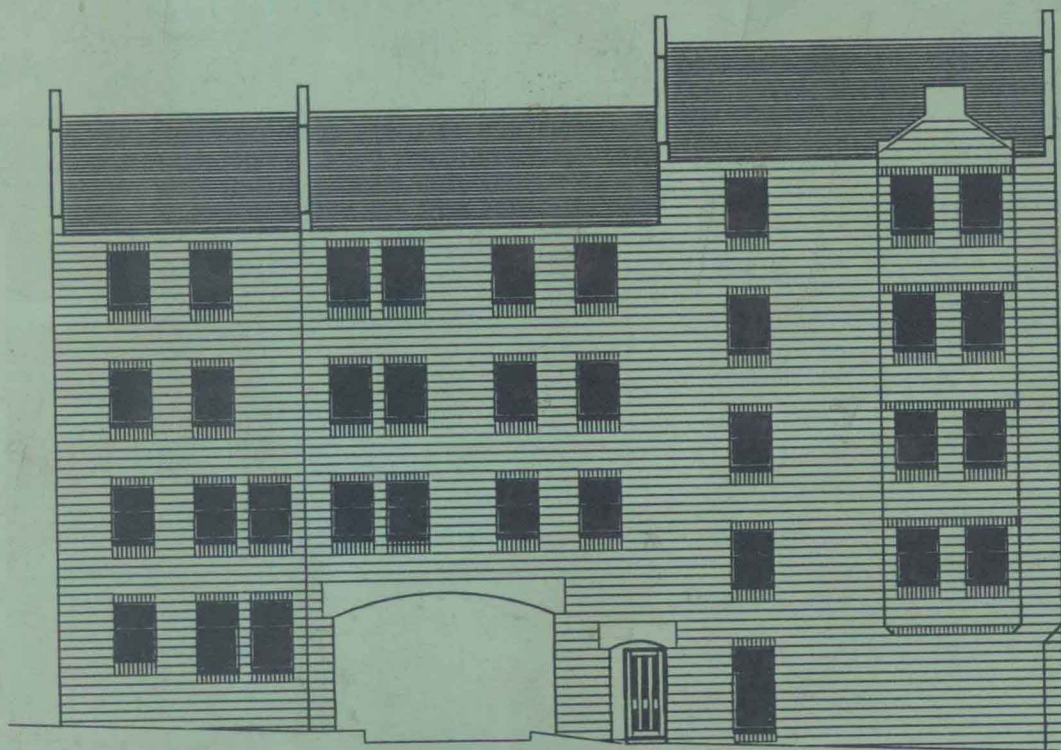




Brighton Metropole Sussex UK
3-5 April 1984

Organized by the journal *Computer-Aided Design*





Brighton Metropole Sussex UK
3–5 April 1984

6th international conference and exhibition on computers in design engineering

Organized by the journal *Computer-Aided Design*

Edited by Joanna Wexler

Butterworths

Published by Butterworths, PO Box 63, Westbury House, Bury Street,
Guildford, Surrey GU2 5BH, UK

Copyright © Butterworth & Co (Publishers) Ltd 1984

All rights reserved. No part of this publication may be reproduced,
stored in a retrieval system or transmitted, in any form or by any means,
electronic, mechanical, photocopying, recording or otherwise, without
the prior permission of Butterworths.

ISBN 0408 01 4407

Printed in Great Britain by
Biddles Ltd, Guildford, Surrey

CAD84

CONFERENCE SPONSORS

CAD Centre

CAM-i

CICA

Displays Group, British Computer Society

Institution of Civil Engineers

RIBA

VDI

Organized in cooperation with ACM SIGDA (the US Association for Computing Machinery Special Interest Group on Design Automation)

CONFERENCE COMMITTEE

J Amkreutz

I3P – Raadgevend

Ingenieursburo,

The Netherlands

F J Barnes

Universidad Nacional Autonoma
de Mexico

Professor P Bézier

Paris

A Coultas

Whessoe Technical and
Computing Systems Limited, UK

Professor C M Eastman

Carnegie-Mellon University, USA

Professor W S Elliot

Imperial College of Science and
Technology, London

P W Foulk

Heriot-Watt University, UK

Professor J S Gero

University of Sydney, Australia

B Gott

CAD Centre, UK

D P Greenberg

Cornell University, USA

D J Grover

British Technology Group, London

J Hatvany

Hungarian Academy of Sciences

A Kociolek

Centre for Building Systems R & D,
Poland

G Lang-Lendorff

Kernforschungszentrum Karlsruhe
GmbH, West Germany

M E Leesley

Michael Leesley Consulting, TX,
USA

W H P Leslie

East Kilbride, UK

Professor T W Maver

ABACUS, UK

Professor S Ohsuga

University of Tokyo, Japan

M Sabin

Fegs Limited, UK

Professor T B Sheridan

Massachusetts Institute of
Technology, USA

W M vanCleemput

Stanford University, USA

Professor J Villadsen

Instituttet for Kemiteknik,
Danmarks Tekniske Højskole,
Denmark

Conference Organizer

Joanna Wexler

Conference Secretary

Sue Mitchell

FOREWORD

Welcome to CAD84, the sixth in the series of international conferences and exhibitions on computers in design engineering. The series, organized by the journal *Computer-Aided Design*, is an established international forum on the state-of-the-art in CAD and CAD/CAM.

This year's conference has two main streams. Two new sessions have been added, covering the important talking points of expert systems in CAD and process plant design. These join sessions on CAD in architecture, CAD/CAM, control, design techniques, drafting systems, electronics, geometric design, kinematics, mechanical engineering, solid modelling and structures. Also included are the Systems Purveyors presentations, where delegates may hear about commercial systems.

The exhibition, running alongside the conference, has again expanded enormously in size and numbers demonstrating that CAD has become part of the everyday working environment in many industries. Here you will find the hardware, software and services for your particular application.

I would like to thank the members of the conference planning panel for their efforts in refereeing the submitted papers, assembling the conference programme and chairing the sessions. Thanks are also due to the conference sponsors and co-operating bodies. I am grateful to the authors for responding to the call for papers to provide such a valuable state-of-the-art reference volume of CAD activity world-wide.

I hope that at the conference sessions, at the exhibition and during the social events you will develop new ideas and friendships that will ultimately help to increase the benefits of CAD to all.

Joanna Wexler
Conference Organizer

CONTENTS

Foreword	xi
----------	----

Invited presentation: CAD/CAM; past, requirements, trends <i>P Bézier</i>	1
--	---

A versatile and accessible interface management system <i>M Lamb</i>	7
---	---

DRAFTING SYSTEMS

Language for definition and manipulation of parametric graphic representation <i>C Devoti, P Galli and V Cugini</i>	15
--	----

Idim – an interactive data input model <i>Z Grodzki and M Winiarski</i>	16
--	----

On design of the drawing system to support various styles and practices <i>C Liu</i>	23
---	----

Automated drawing and cost estimation program for platform frame construction: House 24 <i>A Ishigami</i>	38
--	----

ELECTRONICS

HILO-2 – a system to build on <i>R L Harris, S J Davidmann and G Musgrave</i>	48
--	----

Time-domain temperature-dependence simulation of MOS electronic circuits <i>V Litovski and B Petkovic</i>	61
--	----

CADIC: an efficient integrated circuit design aid <i>G B Swan and J D Eades</i>	67
--	----

STRUCTURES

Computer-aided design of timber space frames <i>B H V Topping and D J Robinson</i>	74
---	----

Interactive reliability-based optimum CAD of framed structures <i>D M Frangopol</i>	89
--	----

Interactive synthesis of engineering structures <i>Z M Bzymek</i>	97
A comparative study of search techniques for the optimization of plane frames with bending moment constraints <i>K R Krishnan and M Gopalakrishnan</i>	104
GEOMETRIC DESIGN	
Recursively generated B-spline surfaces <i>A A Ball and D J T Storry</i>	112
Non-nodal interpolation – an improved technique for the uniform B-spline method <i>J Chen and J Wu</i>	120
A design system for products with sculptured surfaces <i>T Dokken</i>	130
Surface fitting using boundary data <i>G Mullineux</i>	137
CAD IN ARCHITECTURE	
The impact of CAD on architectural practice – challenges, benefits and prospects <i>P L Selby</i>	148
The organisational implications of CAAD <i>S E Little</i>	156
A computer-aided architectural design technique for the appraisal of domestic activity spaces <i>K Langskog and L W W Laing</i>	165
An alternative to the daylight evaluation chart <i>E J Fishhaut, N H Weingarten and C Neiger</i>	182
CADCAM 1	
A hierarchical machine design system Himades-1 based on the structure model for machine <i>K Kitajima and H Yoshikawa</i>	193
The LINKA interactive computer graphics system and its TPVR program <i>S Wenyuan</i>	208
Development and use of a CAD/CAM system for complex surfaces <i>M J Bryan, J Stark and P Parkin</i>	217

VISUALIZATION

Winsom – a general surface drawing program
P Quarendon 223

CAPITOL: a low cost 3-D modelling and visualization system for
interior designers and architects
C A G Webster 224

SOLID MODELLING 1

Interrogating solid models
A F Wallis and J R Woodward 236

RSC: a calculus of shapes
F Arbab 244

A dimension based parametric design system
G Parden and R G Newell 252

KINEMATICS

An experiment package for geometric modelling of mechanisms
N-X Wang, W-B Wen and R-X Tang 260

Frame timing techniques for the dynamic description of kinematically
assembled mechanisms
A J Medland 271

Optimum kinematic design of machine tool gear boxes
N K Mehta, P C Pandey and P C Misra 286

DESIGN TECHNIQUES

An application of graph theory in plotting finite element mesh
R Sandanadurai and N Nackeeran 298

GAME: an interactive graphic system for automatic mesh generation
E Bon, M Casanova and G Grassi 307

Design optimisation – a modular interactive approach
R McCafferty 316

GDOC: a tool for computer-aided design of database applications
F M Ferrara and C Batini 325

PROCESS PLANT DESIGN

Effective, highly interactive CAD system for making isometric piping-drawings programmed for desk-top computers <i>J Poikonen</i>	339
End-user oriented design of a flow sheeting computer aid in minerals processing <i>L C Woollacott</i>	348
The next generation in process-plant CAD <i>M Hall, T Curry and D Hancock</i>	360
ISOSTEEL – an integrated system for load-bearing steelwork analysis and design <i>D Button</i>	367
Flexibility in CAPP through system design <i>S Evans and P J Sackett</i>	385
Commercial piping CAD databases <i>W G Beazley</i>	394

CADCAM 2

Accommodating a turnkey CAD/CAM system to organizational needs <i>M Tervonen, H Lehtikoinen and T Mukari</i>	413
AUTOMODL; a 3D modeller for welded steel structures <i>K Jacobsen</i>	422
A multi-discipline and integrated facility for management and evaluation of engineering data <i>F J Heerema and H A Kreijkamp</i>	431
Automated design of crankcases: the Carter system <i>M Reynier and J M Fouet</i>	444

SOLID MODELLING 2

Creating large solid models for NC toolpath verification <i>A F Wallis and J A Woodwark</i>	455
An introduction to relational topology <i>P Hanrahan</i>	461
A new method of view synthesis for solid modelling <i>W L Chung</i>	470

Synthesis of volume modelling and sculptured surfaces in BUILD <i>G E M Jared and T Varady</i>	481
CONTROL	
The frequency response determination of hydraulic drive and control systems and elements by means of a computer <i>H Chrostowski</i>	496
Microcomputer-aided microprogrammed control-unit design <i>V Dvorak</i>	507
A CAD program for optimal digital control systems <i>T P Wang, J M Tian and S W Wang</i>	515
EXPERT SYSTEMS 1	
An extended expert system for display management in a CADD system <i>J H Boose</i>	522
The place of expert systems in architecture <i>J S Gero and R Coyne</i>	529
Automated configuration of backplane-based micros <i>J A Bowen</i>	547
New rules of thumb from computer-aided structural design: acquiring knowledge for expert systems <i>A D Radford, P Hung and J S Gero</i>	558
MECHANICAL ENGINEERING	
CAD of power shafts for various design theories <i>B Kaftanoglu and P K Nguyen</i>	567
Integrated design system for induction motors <i>I Fučík and V Klevar</i>	579
Computer Aided Design of hydraulic components bodies <i>K Grossmann</i>	590
Improving productivity in turbine design <i>J H Eskesen and C L Stahly</i>	598
Author index	607

Pierre E Bézier

After briefly reviewing the major stages of CAD/CAM, the progress that has been made in hardware and software is described.

From these facts, are deduced some trends, giving a picture of the not too distant future.

* * *

Après un bref rappel des étapes principales de l'évolution de la CFAO, on décrit les progrès accomplis par les moyens matériels et logiciels nécessaires à son développement.

De ces données, on essaie de déduire quelle pourrait être l'évolution dans les années prochaines.

1. RETROSPECT

Without any doubt, the advent of the computer is one of the major causes of the improvement in industrial practice. Moreover, numerical control and CAD/CAM are among the most important technical as well as sociological achievements.

This evolution has been so fast and so complete that we are liable to forget some important points, and it may be profitable to cast a glance over the past and briefly recall the most significant steps.

In 1942, the first computers appeared. One of them, probably ENIAC, was used to define the motion of a milling cutter manufacturing a camoid forming part of an aircraft engine automatic gas control system. A little later, BENDIX-AVIATION operated a special milling machine for cutting gas turbine foils.

This was not yet true CAD, but it was a great help for engineering the production of highly difficult parts.

In 1955, twenty numerically controlled machine-tools were displayed at the Chicago Machine Tool Show. Industry then began to pay real attention to this technique.

In 1958, the APT program was intended to help engineering of production operations. It dealt with "conventional" geometry, lines, circles, sometimes parabolas, and a few polynomial curves.

At about the same time, the aircraft and automotive industries began working on the problem of defining space curves and "twisted" surfaces, which are found in wings, fuselages and car bodies.

In 1964, James C Ferguson, of the Boeing Co., published a paper on "Multivariable Curve Interpolation" in the Journal for Automatic Computing Machinery. The polynomial expression was limited to degree 3×3 .

In 1965, the SKETCHPAD project, by MIT and IBM, associated computing and drawing.

In 1967, Steven A Coons published project MAC from MIT: "Surfaces For Computer-Aided Design of Space Forms".

The objective was to describe completely four-sided patches whose boundary lines were given, ensuring at the same time slope or curvature continuity between adjacent patches.

In 1968, Doctor Robin A Forrest, now a professor at the University of East Anglia, was working in the Cambridge University Mathematical Laboratory of Professor Wilkes. After spending some time with Steven Coons, he wrote his Ph.D. dissertation on "Curves and Surfaces for Computer-Aided Design".

At about the same time research was being carried out in this area in Great Britain by Charles Lang, ARMIT, Malcolm Sabin, Flutter, etc. and even Mehlum in Norway.

A brief description of the principle of the UNISURF system appeared in the French technical press.

In 1969, William Gordon and Richard Riesenfeld's papers on Multivariate Approximation appeared in the Journal of the Society for Industrial Application of Mathematics, and in notes inside General Motors Co.

Since that time, a great amount of work has been performed around the world on this subject: USA, Canada, Western Europe, Japan and China. Little is known about the results of work carried in Eastern Europe.

Most systems, if not all, are based on the use of parametric polynomial functions with vector coefficients.

2. EVOLUTION

The progress of the means that are available largely reacts on the evolution of a system. Consequently, it seems advisable to briefly describe the changes that have taken place during the last twenty years, in both hardware and software.

2.1 Hardware

So great has been the improvement in the possibilities of computers that it seems difficult to describe it by figures for speed, power, cost or volume. Most of them should be expressed by two orders of magnitude, and sometimes three. Until about 1960, analogue and digital

computers were still competing; the capacity of a memory was expressed, at the utmost, by a few kilo-octets, and the accepted idea was that a company should have a huge monster of a central computer working, simultaneously, for the benefit of every department.

Now, connecting together large, medium, mini and microcomputers has decreased the cost and the volume of a system, and it can be safely admitted that speed has been increased by a coefficient close to two or three orders of magnitude.

Designing an object entails displaying its image; a drawing is quickly obtained on a cathode ray tube (CRT) and it is easy and fast to rotate, expand or alter it; the accuracy is not very great, but this is seldom important. It is difficult to pass a final judgement regarding the aesthetic value of a project, even when it is displayed by a coloured and shaded image.

On the other hand, drawing board accuracy can be excellent, sometimes about 1/10,000, which is very useful when tracing maps, charts or templates. The speed of the tracer is commonly 300mm/s and sometimes 500, for motor driven machines, but magnetic control is even faster; the surface is flat, which makes aesthetic judgement easier; the total dimension can exceed ten meters and one of the major advantages is the ability to produce a full scale drawing on a plastic sheet that is very, if not perfectly, stable.

To obtain a true three-dimensional image, some drawing offices are equipped with specially designed milling machines intended to manufacture soft materials such as styrofoam, plaster, wood, resin and, sometimes, metal. They have a very fast feed, up to 200mm/s but the spindle power needs not be very great ie 1 or 2 kW.

2.2 SOFTWARE

CAD/CAM involves three major activities: computing, tracing and manufacturing models.

When an object has to fulfill some technical requirements, computation is first performed for determining a few basic dimensions related to physical phenomena such as stress, deflection, fluid dynamics, etc.; then, from these data, a rough sketch is drawn and then, iteratively computing and drawing, the final shape is defined.

The manufacturing process is first related to the definition of the surface and that of the cutting tool, and the program has much in common with the shape of the object itself, since it is important to avoid deflection, distortion and chatter.

Architectural drawings are mainly based on lines rather than curves, but the deletion of hidden lines is compulsory, as well as the use of a very complete database for standard components.

The tracing of the shape of an object raises a twofold problem: mechanical parts, for centuries, have been traced with compasses, T square and straightedge; some details, such as fillets or draft, being left scantily defined, to be taken care of by craftsmen, highly skilled patternmakers, diesetters, etc.; some programs, e.g. APT, etc., have incorporated the properties of lines and circles, together with those of analytic simple curves, surfaces or volumes - mainly planes, cylinders, cones, spheres and toruses.

To deal with some physical phenomena and with aesthetics, a greater variety was required and, among many solutions developed the parametric curves are the only ones which have survived in practice.

Before the advent of CAD/CAM, the accepted practice for defining a surface was to trace cross-sections on a drawing, then to carve them in a block of material such as wood, plaster, resin or metal, finally leaving it up to craftsmen to interpolate between them and obtain the final shape of the model.

Steven A Coons was requested to devise a mathematical solution for a similar problem but, instead of cross sections, he was given a net of parametric curves entirely covering the surface; he built a complete definition of each mesh, ensuring slope and curvature continuity between them.

His system, based on tensor calculus, is considered a major milestone in CAD and gained him well deserved world-wide fame.

A little later, the possibilities of the COONS method were somewhat expanded with the help of characteristic polygons and nets. It seems that the improvement lies in the possibility to deal with degenerate patches and to make geometric properties easier to grasp and predict for the layman.

Then William Gordon and Richard Riesenfeld published in 1969, a solution also based on parametric spaces together with special interpolating functions; their system can be totally automatic, but the operator can also control it.

Since that time, solutions have appeared, by the name of CONSURF, B-splines, H-splines, K-splines, β -splines, etc. which apply mainly to cubics and which differ by the method for controlling the moduluses of the first end-derivatives.

Moreover, CAD/CAM has taken advantage directly or indirectly of the mathematical research carried throughout the world, by scientists such as Professors Cox, De Boor, Boehme, Sablonniere, Chang, Wu, etc. not to mention Malcolm Sabin who attacked, and solved, the problem of n -sided patches.

It can be broadly stated that, up to 1975, most of the work concentrated on the description of surfaces, since the main interest was focused on the definition and manufacture of experimental shapes, either technical or aesthetic: propellers, turbine foils, boat hulls, car bodies, aircraft, etc.

About that time, more attention was paid to mechanical parts, and the prospect changed: instead of connecting surfaces delimiting a volume, the shape of an object became a boolean combination of volumes: prisms, pyramids, cylinders, cones, spheres and toruses. This has been named "solid modelling"; the systems are many and include e.g. Applicon, Compac, Computervision, Datavision, Euclide (French), Euklid (Swiss), RA3D, etc.

Now it seems necessary to mix analytic and parametric surfaces and volumes; up till now, little has been published on that matter, though a large amount of work has been oriented towards the resolution of this problem.

The parametric surfaces and volumes have an evident advantage for the definition of parts that are submitted to finite elements computation for stress and vibration research.

3. FORECAST

From our present knowledge, can we imagine a future CAD/CAM?

First of all, it is certain that more and more will be expected from it.

Speed is a major value. Many an operator now complains that he has to wait for one or two minutes in front of a CRT before obtaining the result of an intersection or of a rotation; very likely, he has forgotten that, fifteen years ago, it took a couple of weeks to obtain the answer, which was sometimes not very accurate; maybe, he never knew. Anyhow, speed will have to be increased in order to comply with the request of most of the users.

Accuracy is only required at the final stage, for tracing a map, milling a template or sculpturing a die or a stamping tool. A slight distortion on the screen of a CRT or on a drawing table is not important since the vital data are exclusively carried by figures, the drawings and the models being nothing more than auxiliary information.

Possibly, large liquid crystals boards will compete with

drawing machines, but the problem will remain to produce and keep good hard copies in the files.

For a stylist, it is vital to actually see and even touch a 3D object. Hence the importance of hidden line removal, perspective views, light reflection lines, colour and shading of CRT images. Possibly, holography will bring another solution but, very likely, it will need very powerful software.

Picking up 3D coordinates on a model is performed with the help of styling bridges or of photogrammetry. It is not unrealistic to consider that laser or sound telemetry would speed up this operation.

Inputting data for a 2D drawing via a keyboard, a joystick or a lightpen is easy and fast, and this leaves little to be desired. For a 3D figure, the "magic wand" of Evans & Sutherland gives good results and similar systems could use light or sound detectors.

For performing actual experiments, a 3D model is an absolute necessity. Some drawing offices and research departments are already equipped with fast milling machines; it seems predictable that this tendency will develop; maybe a laser will remove material faster than any cutter; it would help to have a fast curing material that would be spread with enough accuracy so as to minimise, or even nullify, the need for a subsequent machining.

Solid modelling will expand, and it seems compulsory to mix so-called "analytic" volumes and parametric entities, especially with a view to defining surfaces similar to variable radius fillets connecting patches. One hypothesis that should not be overlooked is that lines, circles and planes can be considered special cases of approximation by parametric curves and surfaces. Consequently, analytic entities could be included in parametric geometry rather than added to it.

Regarding the basic principle of CAD, two systems can be considered: translating an existing handmade shape or creating it directly with the help of figures.

The second method is simpler and faster, provided that the mathematical basis is easily understood and manipulated by designers and technicians without needing a special training in parametric geometry and tensor calculus. Its most evident advantage is that the definition of a shape is complete and indisputable, and that it can be transmitted completely distortion-free, without place for argument between people in charge of design and any other department dealing with production or inspection.

More and more companies are, or soon will be, using CAD/CAM. It is vital that the exchange of data between them and their associates or subcontractors be extremely easy. Geometric definitions and computers programs should be totally compatible. For the time being, this is far from being the case, but it is high time this point be seriously considered. This is perhaps, one of the major problems that specialists have to solve, and the International Standards Organisation (I.S.O.) has a vital part to play in such a task, one of the most urgent we are faced with.