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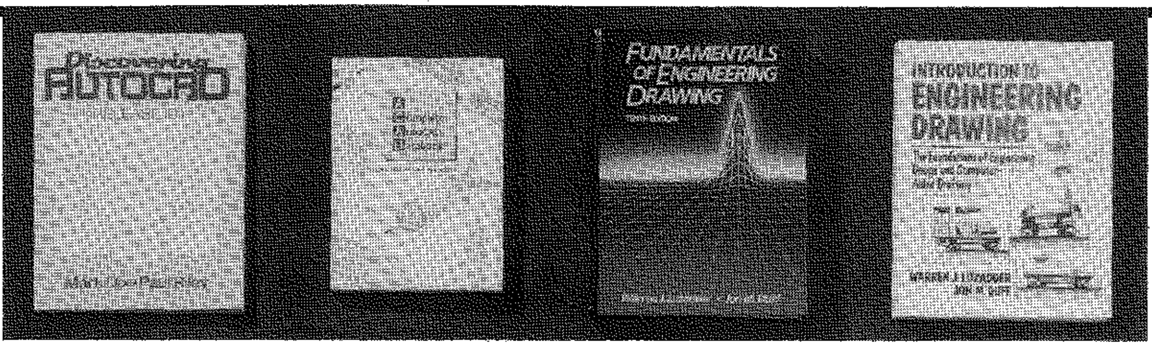

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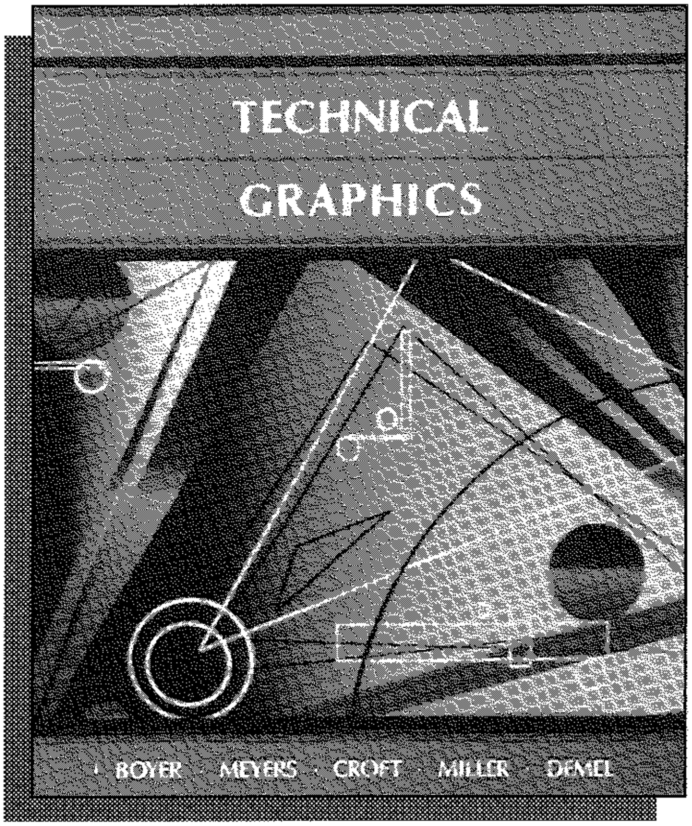
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The Development of a Multi-Media Instructional Package for CAD

Leonard O. Nasman

Engineering Graphics Department
The Ohio State University
Columbus, Ohio

(Recipient of the
1990-91 Oppenheimer Award)

Introducing large numbers of engineering majors to CAD provides a special instructional challenge. To meet this challenge, The Ohio State University Engineering Graphics Department has evolved a multi-media approach for CAD teaching. Also being developed is a complete "on-demand" training system for future use.

Introduction

At Ohio State, a challenge is to introduce all students majoring in engineering to Computer Aided Design (CAD). This implies that about 1000 students go through a required course sequence in engineering graphics in one year. Several years ago, CAD was integrated into this required course sequence. The large number of students taking the course requires that there must be fairly large multi-sectioned classes (up to forty students) taught by both experienced professors and by less experienced graduate teaching assistants. Not only will the current use of the multi-media approach be described, but also the future incorporation of even more advanced instructional technologies will be outlined.

The Setting

Rather than standing as a separate class, CAD has been integrated into the required engineering graphics course at Ohio State. There may be up to fifteen sections of thirty to forty students per section in a given quarter. Naturally, this requires that a large number of graduate teaching assistants and regular faculty be involved in teaching CAD. Since each student receives credit for the same course, it is important to provide as much consistency as possible between sections.

After much deliberation relative to considerations of user interface, cost, hardware requirements, and site licensing considerations, CADKEY was selected as the software for the CAD portion of the course. A student version of CADKEY is made available through the campus computer store for those students who have access to computers outside of the graphics computer laboratory.

The Engineering Graphics Department has equipped former conventional-drawing laboratories with an instructor console which contains the following (Fig. 1):

a VHS/VCR for showing video tapes,
two computers,
an overhead color video camera focused on an auto-shift drawing table,
a passive video switch for switching between video sources.

The laboratories are also equipped with monitors so that no student is more than fifteen feet from a 19" monitor (Fig. 2). These rooms are used for instructional presentations and as a traditional drawing laboratory for pencil and paper type assignments.

The Multi-media Approach

Presentation of instructional materials on the use of CADKEY is accomplished through the use of several media and methods. To promote consistency between sections, each instructor shows a series of video tapes developed by Dr. Gary Bertoline (currently at Purdue) and Dr. Leonard Nasman. The tapes average thirty minutes in length. Showing of the video tapes is supplemented by the classroom instructor de-

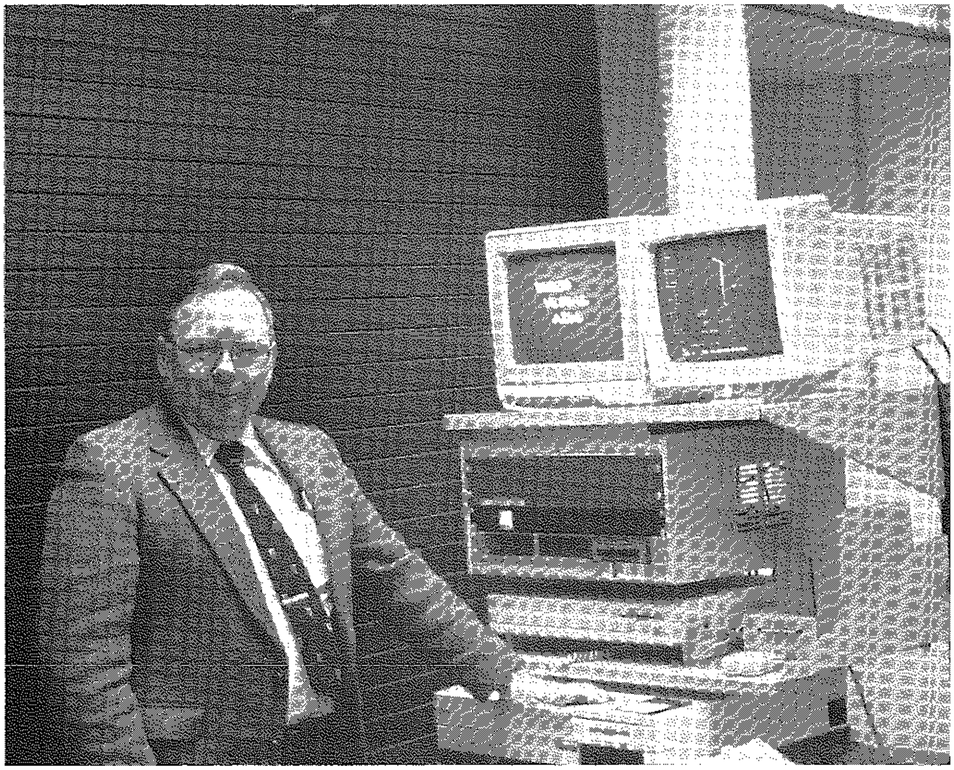

Fig. 1 Video console

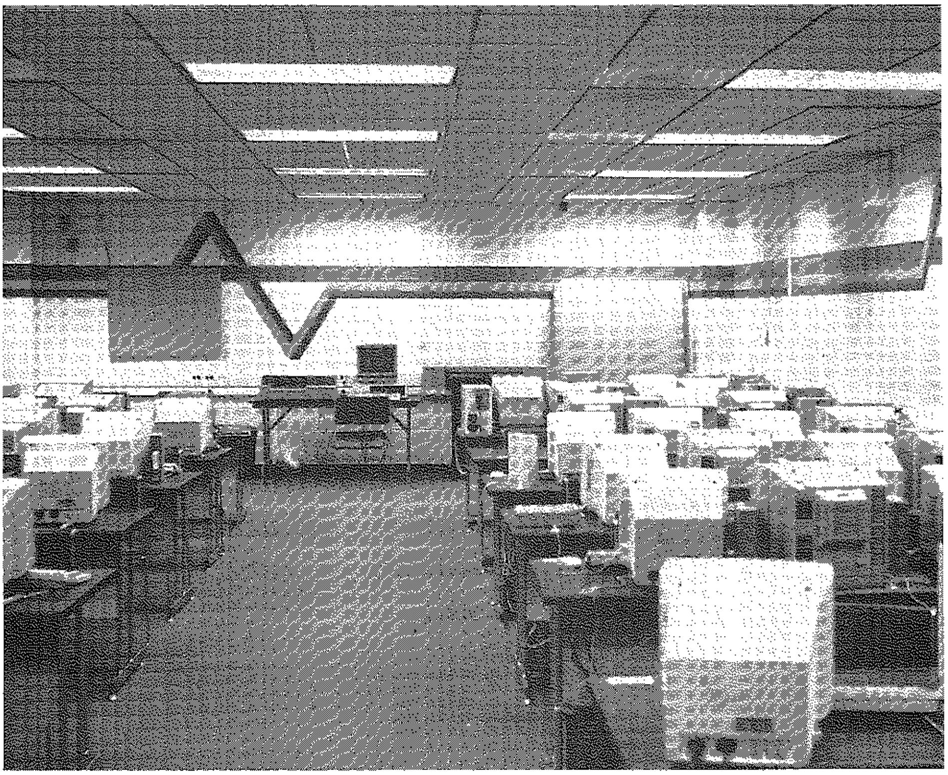

Fig. 2 Drawing laboratory with monitors

monstrating CAD on the console computer, using the overhead camera to present additional information, and through the use of hard-copy handouts containing class notes and CAD assignments. After the multi-media presentation, the students move to the computer laboratory where they work on their CAD assignments.

The Instructional Video Tapes

The video tapes are not simply "canned lectures" on CAD. They show an experienced instructor leading a new user through a carefully designed sequence of increasingly difficult drawing exercises (Fig. 3). The unique assembly of hardware used in producing the tapes allows superimposing the CAD display over the video display. By superimposing displays, the viewer sees both what the operator is doing, and how the system responds. The feeling is much like one would obtain if looking over the learner's shoulder. The learner on the tape makes the mistakes that most new users make, and the viewer has the opportunity to see the instructor help the learner correct these mistakes. The instructor uses a mouse-controlled on-screen pointer to call attention to important details or processes. An overhead camera is used within the tapes to zoom-in on operational details and drawing projects.

The content of the tapes is project oriented and each tape covers topics related to a laboratory assignment. Emphasis is

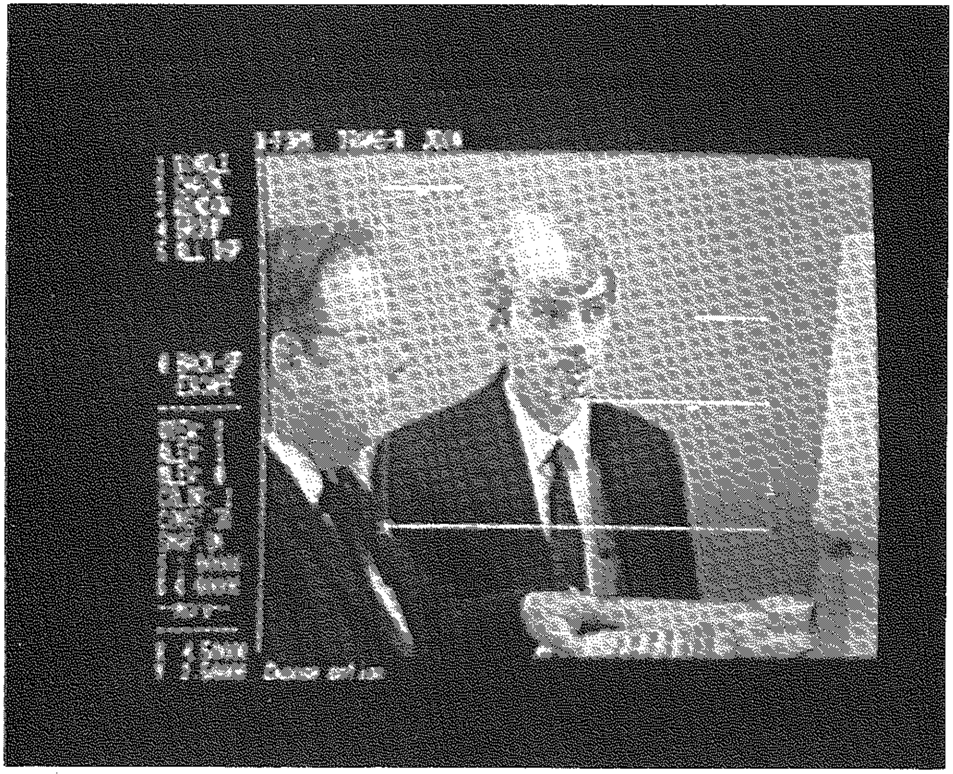

Fig. 3 Video tape display

placed on the rationale for using CAD as well as on drawing technique and specific CADKEY operating features. The primary objective is not to provide skilled CAD operators, but to provide a foundation of CAD literacy.

To overcome the problem of the video tape being a passive rather than an active instructional media, each student is given a "tape watcher's quiz". This quiz has short-answer completion questions, and is an "open-tape" quiz. That is, the student completes the quiz while watching the tape. The quiz has been designed to reinforce important points which are otherwise sometimes missed. Use of the "tape watcher's quiz" has also dramatically increased the attention level of some students.

Once a tape has been shown, the students have the opportunity to ask questions, and the instructor will present details on current assignments. A copy of the tapes is also kept on file in a learning resource center where students may review materials or make-up a missed presentation. The tapes have also been used in an individualized instruction mode for independent study. Immediately following the class session, the students move to the computer laboratory where they complete the CAD exercises shown on the video tape.

The use of multi-media presentations of CAD information has resulted in a dramatic increase in the amount of CAD material that can be covered in the course. At the same time, there has been an equally dramatic decrease in the amount of assistance required in the CAD laboratory. When traditional stand-up lectures were used to present CAD material, it wasn't possible for even three or four instructors to respond to the students' questions promptly (especially the first several sessions). With the use of the multi-media materials, one instructor can handle a laboratory of thirty to forty students without help. This is even true on the first day CAD is covered.

On to the Future

Work is currently being conducted on an interactive videodisc-based version of the CADKEY video tapes. In the proposed version, the student will be running CADKEY on one processor while a second processor is running a CAD help program. As a matter of fact, with the Amiga computer, it is possible to have both programs running simultaneously while sharing the display with the videodisc player. By having a "help" program available "on-demand" (which provides quick access to videodisc CAD instruction materials), the ultimate in individualized CAD instruction can occur.

The Contributed Papers on pages 9 - 47 are sponsored by the Geometric Modeling Committee, one of the Professional and Technical Committees. This committee is chaired by Nadim Aziz of Clemson University, who assumed the responsibility for soliciting and reviewing all papers submitted for this section.

Geometry vs. Descriptive Geometry and Graphics vs. 3D Modeling – In Search of Correct Terminology –

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It is no surprise that some confusion has developed in the field of engineering design graphics; the transfer of the latest computer graphics technology to engineering design graphics has brought some new concepts which collide with the way of thinking that has been in use for centuries. An attempt is herein made to clarify the difference between geometry and descriptive geometry and between graphics and three-dimensional geometric modeling. It is meant to stimulate discussions and promote a constructive exchange of opinions concerning the basic concepts of the engineering design graphics field.

Introduction

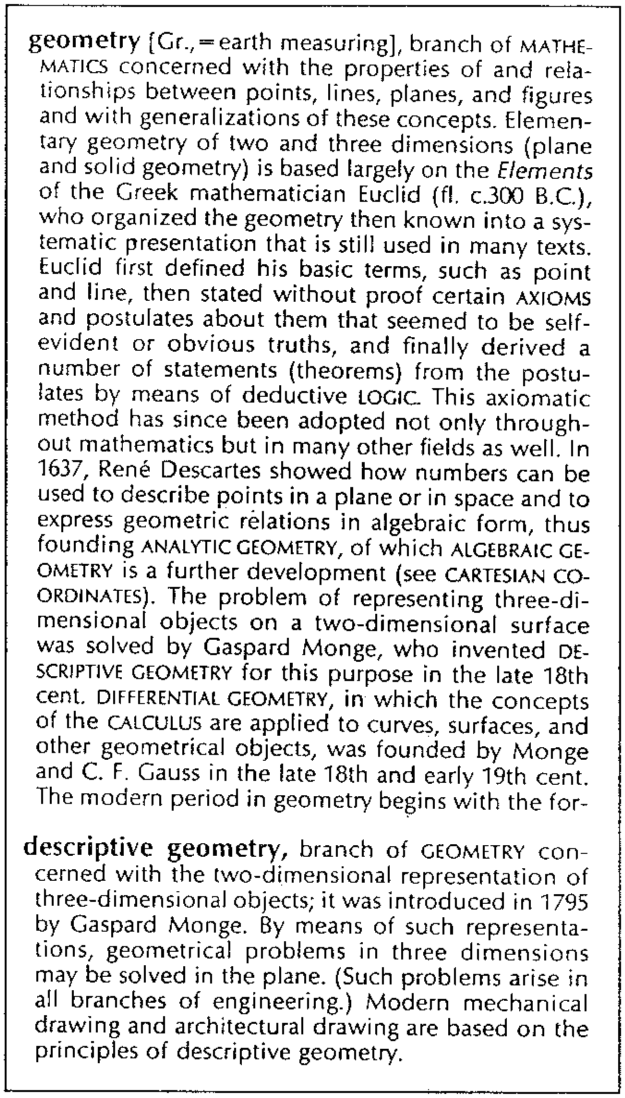
It took two years and a meeting with the European computer graphics community in 1976 for SIGGRAPH's Graphics Standards Planning Committee to realize the difference between geometric modeling and graphic representation of objects. Those software developers that would produce pictorials by using their "move" and "draw" commands could not understand the difference between their approach and the approach of other software developers that were using three-dimensional geometry to describe an object and would obtain the pictorial by displaying its projection. After all, the pictures on the screen looked the same. Ties to tradition, sentimental reasons, self interests, and sometimes just lack of awareness cause one to adhere to outdated concepts, or to extrapolate them beyond their natural boundaries.

The transfer of the latest computer graphics technology to engineering design graphics has brought similar problems. Some new concepts have appeared to collide with the way of thinking that has been in use for centuries. That may explain why some colleagues in the field confuse the concepts of geometry with descriptive geometry and graphics with three-dimensional geometric modeling. There is an interesting case of an author that claims to be teaching descriptive geometry by using a CAD system. His example includes finding the true length between two points by using the built-in CAD function for finding the length of a line. What must be realized is that the computer solution of this problem is based on analytical geometry and not descriptive geometry. For centuries, descriptive geometry methods were used to solve true length and similar spatial problems. New methods, however, do not become part of descriptive geometry just because they solve the problems previously solved by descriptive geometry. In another case a writer claims that all the tools, such as pencil, paper, CAD, or hologram techniques, only " ... enhance the representation of geometric reality and it is all done graphically in one form or another - since a representation (or simulation) is not reality." By his definition the representation in cyber-space (virtual reality) and even by analytic geometry become graphics as they too are not reality. While the term graphics could be redefined to mean anything, such course of action would only increase confusion and postpone the need for clarification.

An attempt is herein made to clarify the difference between geometry and descriptive geometry and between graphics and three-dimensional geometric modeling. It does not intend to "sound like gospel truth". Rather, it intends to stimulate discussions and to promote a constructive exchange of opinions concerning basic definitions of the engineering design graphics field.

Geometry vs. Descriptive Geometry

In order to clarify the terminology in use, it is instructive to consult a dictionary. In one encyclopedic dictionaries, geometry is described as "... a branch of mathematics concerned with the properties of and relations between points, lines, planes, and figures, and with generalization of these concepts"[1]. It also describes related disciplines: analytic geometry, descriptive geometry, differential geometry, and different branches of modern geometry (Fig. 1). From this de-



geometry [Gr.,=earth measuring], branch of MATHEMATICS concerned with the properties of and relationships between points, lines, planes, and figures and with generalizations of these concepts. Elementary geometry of two and three dimensions (plane and solid geometry) is based largely on the *Elements* of the Greek mathematician Euclid (fl. c.300 B.C.), who organized the geometry then known into a systematic presentation that is still used in many texts. Euclid first defined his basic terms, such as point and line, then stated without proof certain AXIOMS and postulates about them that seemed to be self-evident or obvious truths, and finally derived a number of statements (theorems) from the postulates by means of deductive LOGIC. This axiomatic method has since been adopted not only throughout mathematics but in many other fields as well. In 1637, René Descartes showed how numbers can be used to describe points in a plane or in space and to express geometric relations in algebraic form, thus founding ANALYTIC GEOMETRY, of which ALGEBRAIC GEOMETRY is a further development (see CARTESIAN COORDINATES). The problem of representing three-dimensional objects on a two-dimensional surface was solved by Gaspard Monge, who invented DESCRIPTIVE GEOMETRY for this purpose in the late 18th cent. DIFFERENTIAL GEOMETRY, in which the concepts of the CALCULUS are applied to curves, surfaces, and other geometrical objects, was founded by Monge and C. F. Gauss in the late 18th and early 19th cent. The modern period in geometry begins with the for-

descriptive geometry, branch of GEOMETRY concerned with the two-dimensional representation of three-dimensional objects; it was introduced in 1795 by Gaspard Monge. By means of such representations, geometrical problems in three dimensions may be solved in the plane. (Such problems arise in all branches of engineering.) Modern mechanical drawing and architectural drawing are based on the principles of descriptive geometry.

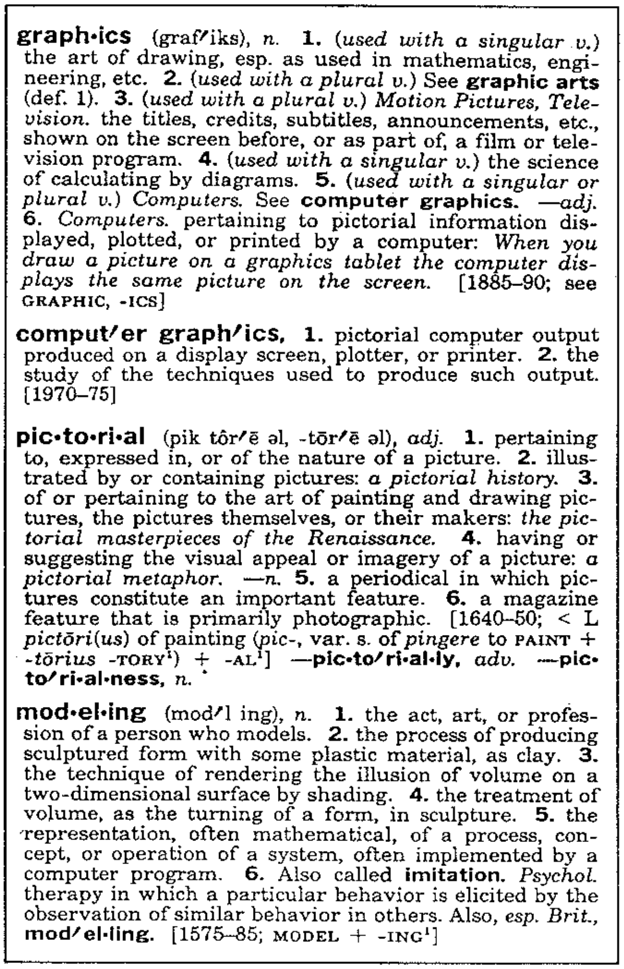
Fig. 1 Some entries from Ref. 1 (Copyright © 1975 by Columbia University Press; reproduced as citation of authority) scription it is obvious that geometry and descriptive geometry are not synonyms, and that descriptive geometry is a branch or sub-set of geometry itself. In the same encyclopedic dictionary, descriptive geometry is described as "... a branch of geometry concerned with the two-dimensional representation of three-dimensional objects"[1].

To solve spatial (three-dimensional) problems, analytic geometry was available much earlier (Descartes, 1637) than descriptive geometry (Monge, 1795), but the lack of tools to facilitate calculations made analytic geometry a very tedious tool indeed. Thus, the graphical procedures established by Monge became the discovery of the century; they could deliver solutions within engineering accuracy requirements relatively fast and with minimal effort. Conditions are different today. Computers can perform complex calculations in a short time, and their programming capabilities make it possible to obtain the solution to any spatial problem as soon as requested. Just because spatial problems have been solved by descriptive geometry during the past few centuries does not make the present way of solving them an extension of descriptive geometry. The period of development and application of analytic geometry (1637-1795, 1985-) is now continuing, and the interim period of descriptive geometry (1795-1985) has come to a close. To simulate descriptive geometry procedures by using low-level CAD functions can be justified only as a sentimental endeavor.

While geometry in general, with its study of properties of and relations between points, lines, planes, and figures, was always, is now, and will be in the future of great importance to an engineering designer, descriptive geometry, which uses a two dimensional medium to solve three-dimensional problems, is no longer a viable option compared to computer-based analytical methods of solution. Geometry of projection, which is frequently considered a part of descriptive geometry, is the only exception. This is actually true only for the "primary" part of geometry of projection. The concepts of primary geometry of projection (projections by definition) will be needed as long as display surfaces are used to represent three-dimensional models. The secondary geometry of projection (i.e., the guiding rules in making projection drawings) is also becoming obsolete. By realizing that the main concepts of descriptive geometry have become useless for an engineering designer, one does not denounce all geometry in general, nor does one declare that geometry has failed it users. Even descriptive geometry did not fail it users; it served them faithfully during its long life.

Graphics vs. 3D Modeling

Consulting a dictionary[2] on the terms graphics, computer graphics, pictorial, and modeling (Fig. 2) reveals that the term graphics refers to the art of producing drawings and to the science of calculating by diagrams. Thus, three-dimensional modeling (not to be confused with



graph•ics (graf′iks), *n.* **1.** (*used with a singular v.*) the art of drawing, esp. as used in mathematics, engineering, etc. **2.** (*used with a plural v.*) See **graphic arts** (def. 1). **3.** (*used with a plural v.*) *Motion Pictures, Television.* the titles, credits, subtitles, announcements, etc., shown on the screen before, or as part of, a film or television program. **4.** (*used with a singular v.*) the science of calculating by diagrams. **5.** (*used with a singular or plural v.*) *Computers.* See **computer graphics.** —*adj.* **6.** *Computers.* pertaining to pictorial information displayed, plotted, or printed by a computer: *When you draw a picture on a graphics tablet the computer displays the same picture on the screen.* [1885–90; see GRAPHIC, -ICS]

comput′er graph′ics, **1.** pictorial computer output produced on a display screen, plotter, or printer. **2.** the study of the techniques used to produce such output. [1970–75]

pic•to•ri•al (pik tôr′ē əl, -tōr′ē əl), *adj.* **1.** pertaining to, expressed in, or of the nature of a picture. **2.** illustrated by or containing pictures: *a pictorial history.* **3.** of or pertaining to the art of painting and drawing pictures, the pictures themselves, or their makers: *the pictorial masterpieces of the Renaissance.* **4.** having or suggesting the visual appeal or imagery of a picture: *a pictorial metaphor.* —*n.* **5.** a periodical in which pictures constitute an important feature. **6.** a magazine feature that is primarily photographic. [1640–50; < L *pictōri*(*us*) of painting (*pic-*, var. s. of *pingere* to PAINT + *-tōrius* -TORY^1) + -AL^1] —**pic•to′ri•al•ly,** *adv.* —**pic•to′ri•al•ness,** *n.*

mod•el•ing (mod′l ing), *n.* **1.** the act, art, or profession of a person who models. **2.** the process of producing sculptured form with some plastic material, as clay. **3.** the technique of rendering the illusion of volume on a two-dimensional surface by shading. **4.** the treatment of volume, as the turning of a form, in sculpture. **5.** the representation, often mathematical, of a process, concept, or operation of a system, often implemented by a computer program. **6.** Also called **imitation.** *Psychol.* therapy in which a particular behavior is elicited by the observation of similar behavior in others. Also, *esp. Brit.,* **mod′el•ling.** [1575–85; MODEL + -ING^1]

Fig. 2 Some entries from Ref. 2 (Copyright © 1987 by Random House, Inc.; reproduced with permission)

two-dimensional representation of three-dimensional models) can not qualify as graphics, unless the term graphics is redefined. In computer graphics, the term graphics relates to pictorial information that is of a two dimensional nature. Currently, the representation of a three-dimensional model is produced mostly on two-dimensional displays; thus, graphics and geometry of projection are used to represent and interpret the model. On stereoscopic displays and in cyber-space, the representation is three-dimensional and no familiarity with the geometry of projection is needed to interpret the model, just as it is not needed when looking at a clay model. To produce and display a stereoscopic image, many disciplines may be involved, including graphics, but they will be transparent to the user. Thus, in the future, an engineering designer may not be using any graphics for descriptive iconic modeling when developing and conveying design ideas^3.

It is difficult to accept the fact that graphics, after centuries of being of prime importance, will play a smaller future role in the discipline that is concerned with developing and conveying of design ideas (i.e., engineering design graphics). That does not mean that graphics as a discipline will disappear. It only means that engineering designers will have better modeling methods. Graphics will be needed in other fields, but less and less for design development, unless the term graphics is redefined to mean descriptive iconic modeling in general. However, it seems more appropriate to accept the fact that a different discipline is now superior in accomplishing a majority of design development tasks and that graphics, except for free-hand sketching, will soon be a choice of the past.

To illustrate how descriptive iconic modeling methodology changed through the engineering design history and to show how graphics is a transient tool for descriptive iconic modeling, let us review the methodology for developing and conveying of design ideas, starting with the past and continuing to the immediate future.

Looking back several centuries, imagine a blacksmith trying to design a part for his carriage or his door latch. He would imagine the part, try to form it according to his mental image, check it by observation, modify it as needed to match his refined mental image, and so on until the part would attain a satisfactory shape. The methodology for developing design ideas was the ideation loop, "imagining - forming - seeing - " (Fig. 3). The methodology of conveying design ideas was simply showing the made part. For more complex parts, a model would be made first, out of wood or other material that is easily formed. The ideation loop was then "imagining - prototype modeling - seeing - ", and the conveyance of design ideas was by showing the prototype model itself.

In more recent times, graphics tools for descriptive iconic modeling were developed. By using descriptive geometry, three-dimensional design objects could be modeled using the convenient two-dimensional medium: the drawing board surface. The methodology for development of design ideas was the loop "imagining - graphics modeling - seeing - ", where graphics modeling was done with free-hand sketching and layout drawing. Engineering drawings were used as models for conveying design ideas. Changes in graphics tools, from T-squares, through drafting machines, to computer-aided drafting systems, did not change the modeling method nor the methodology for developing and conveying design ideas.

In contrast to the past few hundred years, the present is making available a new modeling method: geometric modeling of solids by computers. As a three-dimensional geometric computer model can be more or less complete, the term "solid model" is used to indicate a complete and unambiguous description of a solid. Solid modeling is not a graphics tool; it is a modeling

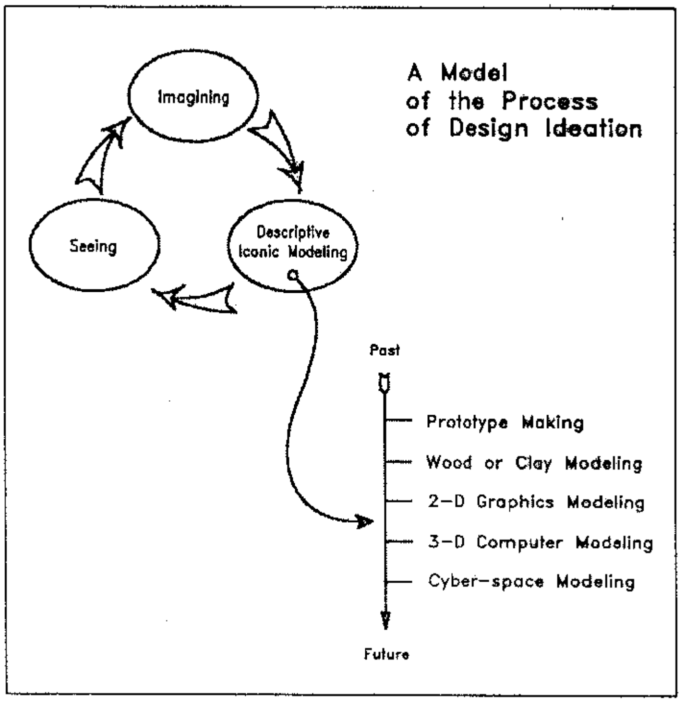


Fig. 3 The ephemeral character of graphics is shown by listing different modeling methods for development of design ideas in the past, present, and anticipated future. (From Ref. 3, reprinted with permission)

method. Thus, it is not comparable to graphics tools like the drafting machine or computer-aided drafting system. It is a natural successor for graphics as a modeling method (Fig. 3). The new ideation loop, "imagining - 3-D computer modeling - seeing - ", does not appear all that different, but the produced model is far different from the one produced on the drawing board. The solid model is a complete and formal description of the designed object in a form that another computer program can unambiguously interpret. It has all the data necessary for engineering analysis, for manufacturing, and for generation of documentation drawings. These data can be transferred directly to respective controllers for processing. Descriptive geometry is not needed to solve spatial problems since they can be solved analytically with more precision and less effort. Projections are not needed any more except for the free-hand sketching phase of the idea development and perhaps for viewing of the three-dimensional model on a flat screen. Engineering drawings are not the primary means for conveying design ideas to engineering analysis and to manufacturing. If drawings are still needed, as may be the case for another decade or so, they are produced from the final solid model instead of being constructed view by view using the rules of the secondary geometry of projection.

Finally, imagine the following not so far-fetched future. A designer is developing his design idea by modeling a part in the cyber-space environment (world of virtual reality). She forms the part just as her predecessor blacksmith was forming it in reality, except that the modern designer works with a virtual part using virtual tools and can shape and reshape the design with ease. This virtual product has all the data of its size and shape precisely recorded at all times. The data describing the final model are sent directly to engineering analysis and to manufacturing. The model can be inspected in cyber-space environment and any inquiry about the data may be made at any time. No drawing, sketching, or any screen projections will be made during this design process, hence no graphics will be used by the designer.

Conclusion

Consequently, the future modeling methods for development and conveying of design ideas that have no graphics content will eventually replace graphics-based modeling. Could this new approach be considered an extension of traditional graphics? According to formal definitions, this would be incorrect, even if one is tempted to do so due to sentimental reasons.

Acknowledgement

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3-D Solid Modeling: Making the Modeling-to-Drawing Interface Seamless

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Conceptualizing 3-dimensional geometry and transforming it to a 2-dimensional piece of paper or computer screen is a difficult process for many students of engineering and technology. An approach to reduce the barrier between 2-dimensional computer aided drafting and 3-dimensional constructive solids modeling is graphically illustrated. This process, or some derivative, encompasses a significant portion of the future direction for engineering graphics education.

Introduction

A visually documented and illustrated method of utilizing "nearly real-time" 3-dimensional computer graphic solid modeling to enhance the creation of objects and geometric problems by engineering students is presented. What makes interactive 3-dimensional computer graphics so compelling as a learning method? For one thing, it puts the student more directly in contact with the object being modeled or the problem being solved than could ever be achieved on paper or through 2-dimensional computer graphics or manual drawing methods[1]. The development of new and innovative instructional methods based on 3-D visual modeling represent the future of engineering and engineering graphics education.

Realistically, the key factors inhabiting the growth of 3-D microprocessor CADD systems have been cost and the lack of computing power and speed in economical 8- and 16-bit microprocessors to handle the labor intensive calculations required to support interactive 3-D computer aided drafting and design (CADD). While 3-D software developers attempted to solve this problem, 2-dimensional microcomputer CADD software and systems have flourished and captured virtually all of the microCADD market. Once mastered, 2-D CADD offers for the commercial market significant increases in production over manual drawing by automating the drafting process. However, from an educational standpoint, the increased level of visual perception gained by students laboring to grasp complex 3-D concepts and geometries through 2-D software may be no greater than with manual mechanical drawing. Fortunately, a new generation of full

32-bit microcomputer workstations supporting integrated 2-D/3-D CADD applications software is beginning to emerge.

Based on the development of integrated 2-D/3-D CADD software for workstations, an instructional method based on 3-D constructive solids modeling is proposed. Procedures for interactively modeling and defining part geometry in 3-D are illustrated. The extraction of 2-D drafting data as a by-product or subset of the modeling process is proposed and will be illustrated.

It is recognized by the author that AutoCAD, VersaCAD, CADKEY, Silverscreen, and a number of other products are designed or are capable of allowing students to work in a 3-D world. However, these "microcomputer based" CADD products, as of early 1990, lack speed of interactivity or photo realistic screen display capabilities to support the "seamless" modeling-to-drawing and drawing-to-modeling capability proposed. For this reason, a high-end solid modeling system was chosen to illustrate the process. Although the workstation capabilities presented are currently not affordable for instructional purposes, all indications from the computer graphics industry are that this technology will be widely available and affordable during the early 1990's.

Problem Selection

For purposes of illustrating an integrated 3-D modeling and 2-D drafting process, a mechanical part has been selected from a widely adopted university-level engineering graphics textbook[2]. The modeling of this part (Fig. 1) is typical of the type of problem that is often assigned to freshman- and sophomore-level students taking a first course in

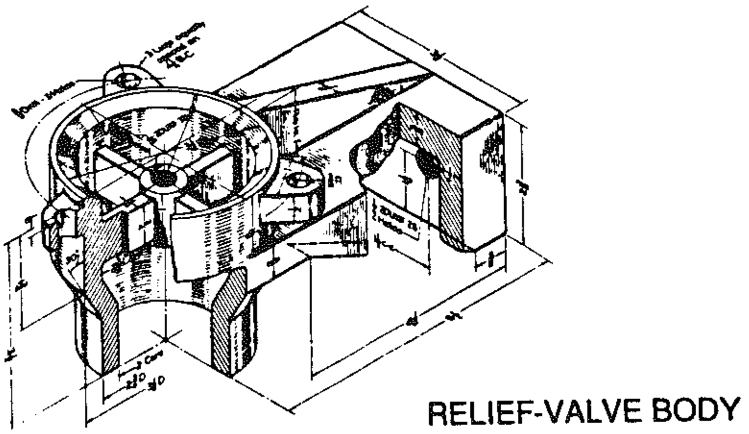

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Fig. 1 Sample Textbook Problem

engineering graphics. The usual objective of an assignment of this type is to have the student make a working orthographic drawing of the part. The finished drawing will typically include all views required to properly depict and dimension the part for production purposes. Even though it might not always be necessary to generate drafting data for manufacturing parts in the future, for purposes of this exercise, that information will be included as a logical by-product.

Visualizing with Solid Geometry

The modeling process utilized here is based on constructive solids geometry (CSG). Three-dimensional software developed from CSG algorithms is based on the concept of being able to create and interrelate 3-D forms known as geometric primitives. At their lowest level, these primitives are commonly referred to by their mathematical names, such as rectangular prism, pyramid, cylinder, or sphere. The primitives (Fig. 2) are then combined either positively or negatively, using Boolean logic, to create more complex solids. A key limiting feature in defining object geometry with CSG modeling is that objects are limited to combinations of linear or radial geometry. Complex boundaries and nonuniform surfaces can be troublesome or impossible to approximate in a CSG environment. Nevertheless, since most machining and manufacturing processes can be described in terms of linear or radial travel, the development and use of CSG based systems is likely to be fairly widespread. The advent of non-uniform rational B-spline (NURBS) and other future advances in the development of 3-D modeling algorithms will eventually allow end users

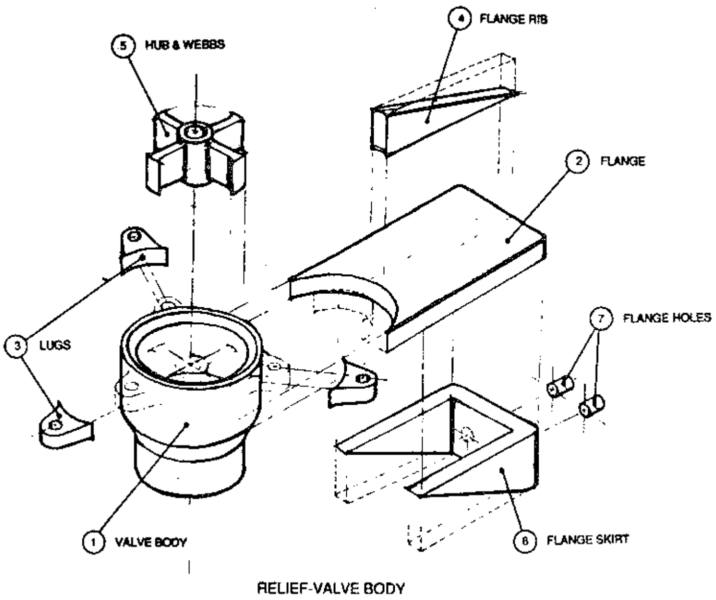


Fig. 2 "VISUALIZED" GEOMETRIC COMPONENTS to accurately define even the most complex geometries with ease.

As an enhancement to add realism to the modeling process, lighting of the model is included. For purposes of this experiment, a Hewlett-Packard SRX parallel processor graphics display controller was added to the hardware. The addition of this device, which supports near real time speed with Gourand Shading and Phong Lighting algorithms[3], added a great deal of visual enhancement and display refresh speed while working through the modeling process.

Although the geometry of the Relief-Valve Body could be described by any number of components or primitives, a combination favoring foundry pattern construction was chosen as a method for visualizing the components (Fig. 2) The geometry of the part is to be constructed or built step-by-step in the same order as the numbering system applied to each component.

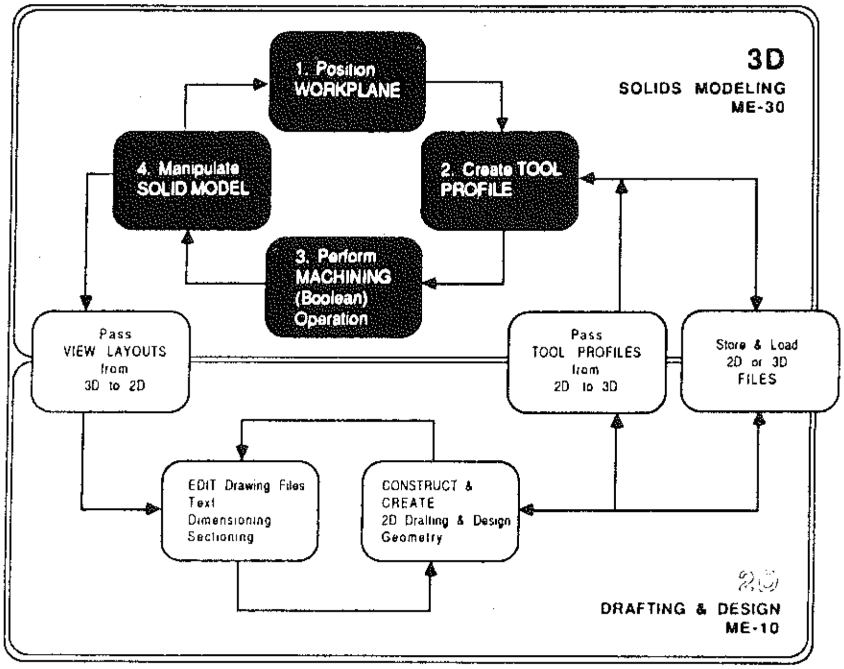
The Interactive Solids Modeling Method

In order for students, designers, engineers, or any end users to work effectively with modeling software, the procedural steps must be well mapped out and as intuitive and interactive as possible. Additionally, to avoid the confusion and abstraction of Boolean logic, the modeling commands should be based on familiar industrial terminology, such as punch, extrude, mill, and stamp, referred to as "feature based" functions. For this experiment the system chosen was a Hewlett-Packard Series 9000, Model 350-SRX microcomputer workstation utilizing H-P's ME 30 CADD software. The procedures used to model part geometry are illustrated in the diagram of Fig. 3 and are repeated for each component of the part.

In order to describe these procedures in a visual manner, Figs. 4 - 6 graphically depict the three steps. For clarity and realism, Fig. 7 and all subsequent figures were photographed directly from the screen of the CADD workstation. For each component operation, the workplane is repositioned and the part is redisplayed in the proper orientation for the next operation in much the same way that an actual part would be handled. Figs. 8 and 9 illustrate examples of the relative positions of the part on the CADD system screen at the completion of specific component shapes. Fig. 10 illustrates the utility of Ray Tracing to enhance viewing of the model transparently[4].

Extraction of 2-D Geometric Data

HP ME-30 CADD software was chosen primarily because it allows automatic extraction of 2-D data from 3-D modeling data. The basic technique involves first revolving and positioning a 3-D wireframe version of the model, as shown in Fig. 11, in a plane parallel or normal to the observer. This is followed by the execution of the special command LAYOUT[5]. The LAYOUT command automatically converts or "smashes" the modeling data onto a plane perpendicular to the viewing direction leaving only a precise 2-D geometric description of the



Principal Operating Procedures
Hewlett-Packard ME Series 10/30 Integrated CADD Software

Fig. 3 Diagram of CSG Modeling Procedures (Courtesy of The Hewlett-Packard Company)

part as it would have been constructed by automated drafting. It is still necessary to edit the 2-D data base, applying conventional drafting practices, and to add dimensions. A screen image of the completed 2-D drafting data base is illustrated in Fig. 12.

Broader Applications for 3-D Solid Models

Admittedly, only one use of 3-D solid modeling was illustrated as a method for generating 2-D CADD drawing files. The procedures of this use are focused on the creation of geometry through integrated modeling and drawing techniques. This is only one of many potential uses for 3-D solid modeling. The 3-D solid modeling data base has a much broader range of valuable uses in such areas as finite element analysis, other measurement and analysis applications, design and production decision making, and other applications relating to manufacturing considerations.

Conclusion

Typically, courses in engineering graphics have had more to do with developing psychomotor skills than developing visual perception. Graphic educators may have assumed that by emphasizing drawing skills, visual perception is always increased. However, the development visual perception may not have been focused upon as a goal to be recognized and developed. Particular kinds of drawing equipment or processes may have been emphasized with the result that a variety of psychomotor skills have been developed, but not necessar-

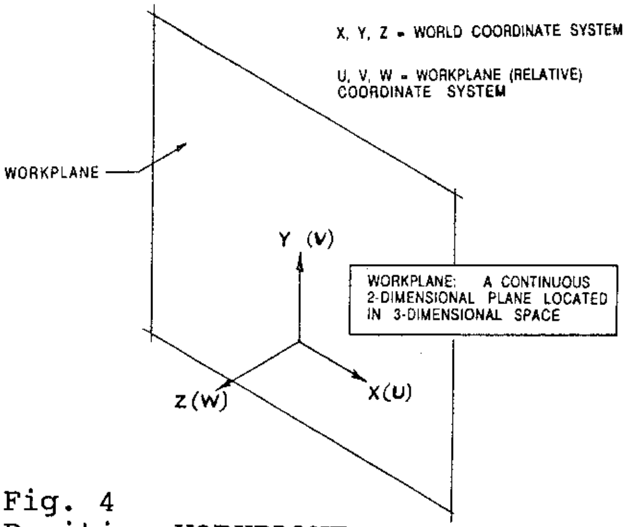


Fig. 4
Position WORKPLANE

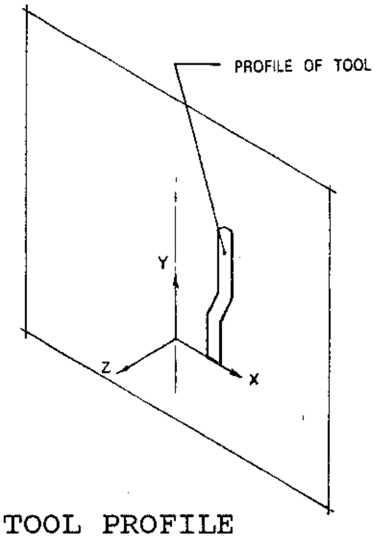


Fig. 5
Create TOOL PROFILE

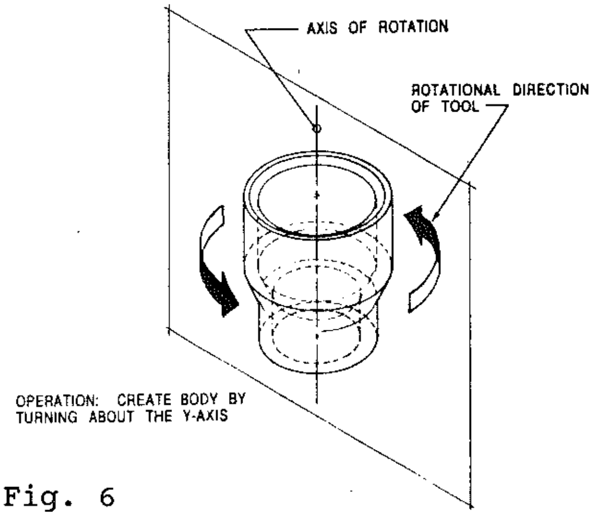


Fig. 6
Perform MACHINING

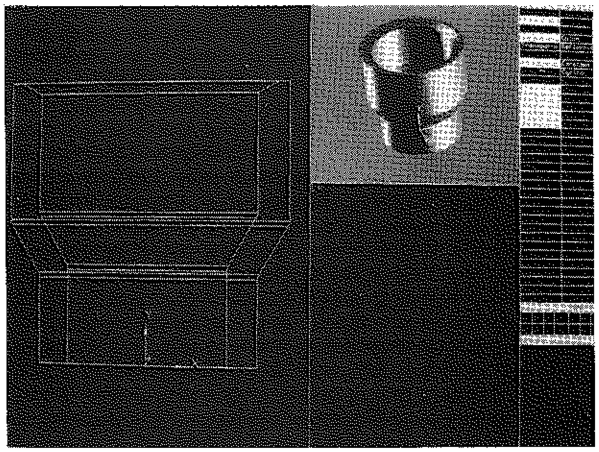


Fig. 7 VALVE BODY

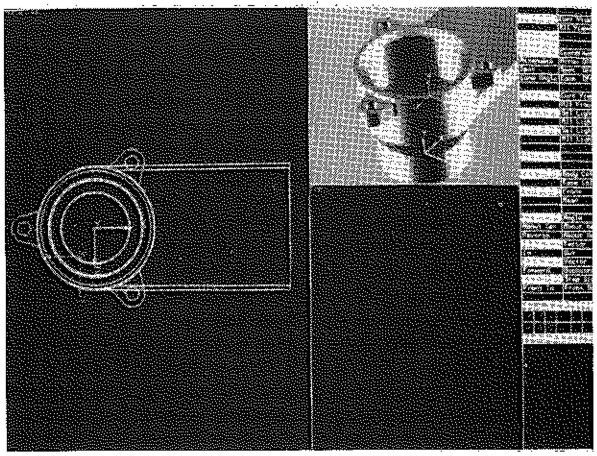


Fig. 8 LUGS

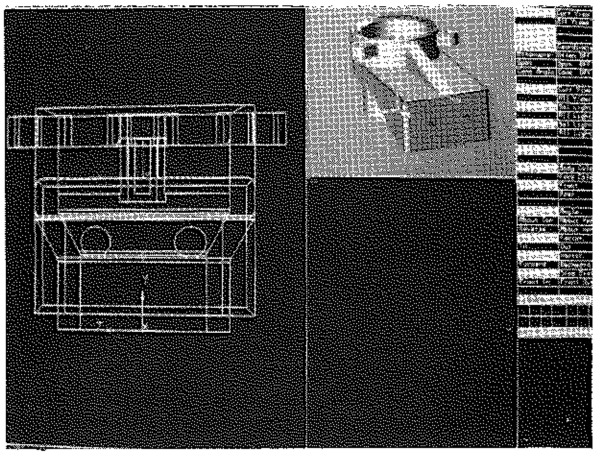


Fig. 9 FLANGE HOLES

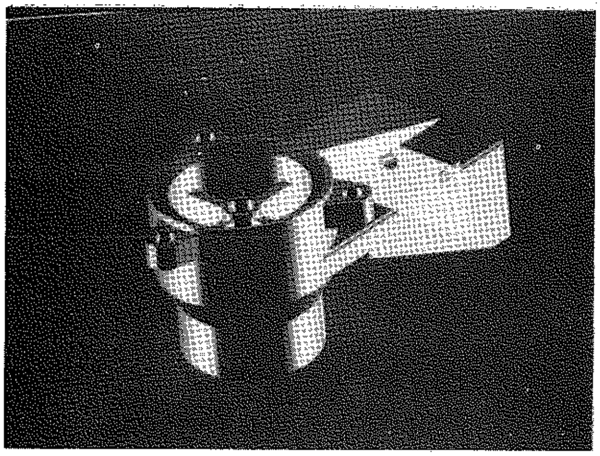


Fig. 10 RAY TRACING TRANSPARENCY

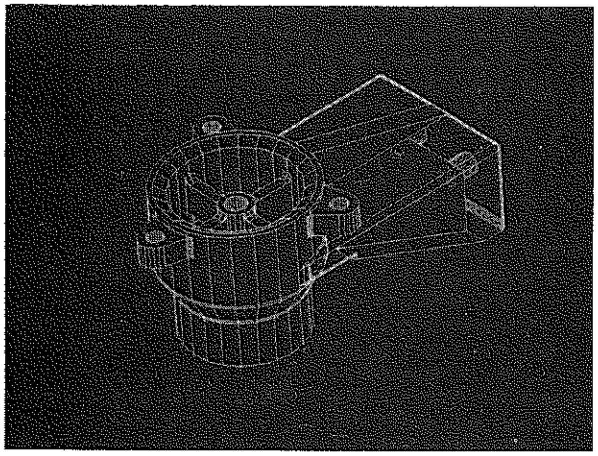


Fig. 11 3-D WIREFRAME FACETS MODEL FOR SHADING

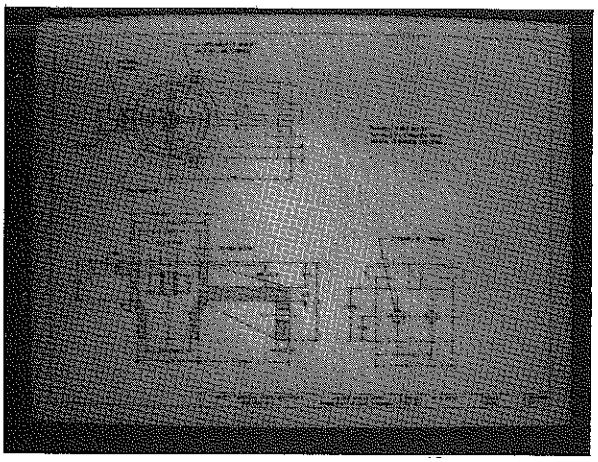


Fig. 12 COMPLETED 2-D DATA BASE

ily visual perception ones. The development of drawing skills may have been incorrectly concluded to equate to "educational success[6].

As a harbinger of things to come, the process outlined in this paper is neither perfect nor a complete solution to the spatial perception problems encountered by engineering and technical graphics educators. Nevertheless, it points the way to alternative methods of approaching problem solving through geometric modeling for the future, particularly when the price tag is lowered. Certainly, the removal of the long-standing barrier between 2-D and 3-D geometry is the key feature. Interactive manipulation and creation of part geometry in 3-D is a primary and unique capability offered through solids modeling. The development of visual depth perception and increased visual insight into understanding the relationship between static 2-D representations and dynamic 3-D simulations of tangible objects and abstract concepts is certain to be redefined and advanced. At a minimum, it is exciting to speculate on the potential for research and development with this type of instruction in the future.

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A Study of Student Procedural Approaches to Creating a Solid Model in a Freshman Engineering Design Graphics Course

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Engineering design graphics curricula across the country are being redefined to incorporate new design tools and methods based on computer-aided geometric modeling. Students at The University of Texas at Austin participated in a pilot EDG course based on solid modeling. The students completed several computer laboratory exercises designed to instruct them in various solid modeling procedures. At the end of the course they were assigned a final design project in which they were required to create a solid model of an assembly. Selection of a procedural approach toward building each component of the assembly was left up to the students. They were, however, required to submit documentation of the solid modeling operations they used for each component. Analysis of these student projects revealed that a number of different procedural approaches were used to create the same models. Some of these approaches were found to be more efficient than others in terms of effort required, size of the resultant CSG file, and time required to display a boundary representation. A detailed description and analysis of the students' various approaches is given. It is suggested that EDG instructors emphasize to students the diversity of possible approaches toward creating a solid model and encourage them to be creative in seeking the most efficient. It is also suggested that studies such as this one might result in the compilation of some useful "rules of thumb" that could help students utilize solid modeling systems for maximum productivity.

Introduction

It is generally recognized that solid modeling is becoming the "de facto" tool for developing engineering designs. The term "solid modeling" refers to computer-aided generation of a three dimensional geometric model of a physical object which describes the space enclosed and occupied by the object. The model can also be assigned physical properties to be used in computerized engineering analysis. Using a solid modeling system, engineers can build, analyze, and modify a mathematical model of a design with a high degree of accuracy in far less time and at a much lower cost than building and testing a physical model. By providing a single model which serves as a common base for design and manufacturing applications, the use of solid modeling shortens the product design-to-manufacturing cycle, which leads to increased productivity and makes the product more competitive. Now that solid modeling software can be used on relatively inexpensive platforms, this technology is accessible to even very small design firms.

The solid modeling approach represents a fundamental change in the methods for developing and documenting design ideas. It is inevitable that traditional engineering drawings will be phased out of industrial practice. The engineering design graphics curriculum must be redefined to meet the needs of students who will be working with this new and radically different design medium. There is an on-going study at The University of Texas funded by the National Science Foundation to develop a modern curriculum for engineering design graphics (EDG) based on 3-D CADD and solid modeling concepts[1]. One result of this project has been the introduction of a pilot course in freshman engineering graphics at The University of Texas. This course is based on the rationale that the geometric model generated during the development stage has all the geometry, as well as other attributes, necessary for engineering analysis and production. It is also recognized that the next decade will probably not see a complete phasing out of traditional engineering drawing used for part description and manufacturing. However, these drawings will originate from the solid model and will need only to have proper conventions and annotations added using a CADD system[2]. A curriculum plan outline for the course is shown in Table 1. Reference 3 provides a detailed description of this outline.

The pilot course, which has been offered to two special sections during the 1989-90 academic year, includes a carefully designed set of solid modeling exercises to instruct students in procedures for creating solid models. Analysis of these exercises clearly shows that there can be several alternative approaches toward building the same model. During the current climate of curriculum modernization from 2-D CADD to 3-D solid modeling, a study of student procedural approaches to building a model can be useful as a guide in curriculum development.

The workstation used by the students for completion of the computer laboratory assignments, as well as the final project, was a Hewlett-Packard Vectra 386-based micro-computer, AT compatible. The software used was AutoSolid for solid modeling and AutoCAD for drafting. Both are products of Autodesk, Inc. The system supports a color ink-jet printer and a 2-pen plotter for hard copies.

Basic Operations in Solid Modeling

As a background for the analysis of student approaches to creating solid models, it is useful to summarize the operations available in a "generic" solid modeling system[4].

1. There is a set of 3-D base primitives used for constructing

Table 1 - Curriculum Plan Outline

Introduction:	**Engineering Design and Graphics** (*1 week*) Role of Graphics in Engineering Design, Manufacturing, and Construction Freehand Line Sketching Techniques
Part 1:	**Graphic Geometry: Elements and Concepts** (*3 weeks*) Planar and Spatial Geometry Geometric Constructions and Tangencies Fundamental Construction Techniques in 2-D CADD Projective Geometry and Visualization Exercises
Part 2:	**Geometric Modeling: Pictorials and Solid Models** (*3 weeks*) Descriptive Modeling as a Design Tool Pictorial Sketching: Axonometric, Perspective, and Oblique 3-D CADD and Solid Modeling Techniques Boolean and Sweeping Operations in Solid Modeling
Part 3:	**Model Applications: Multiview Drawings, Analysis, and Manufacturing** (*3 weeks*) Generation of Multiview Drawings from Model Model Analysis of Geometric and Mass Properties Model Mesh Generation for Finite Element Analysis Generation of Manufacturing Data Files from Model
Part 4:	**Design Documentation: Production Drawings and Data Communication** (*3 weeks*) Multiview and Auxiliary View Drawing Techniques Sectioning and Conventional Practices Dimensioning Practices Production Drawings Graphs and Charts
Project:	**Final Design Project** *(2 weeks)* Planning Sketches 3-D Geometric Models and Assemblies Working Drawing Package

the model. These normally include, as a minimum, the box, cylinder, cone, wedge, and sphere.

2. User-defined primitives can be created by sweeping a contour or profile either linearly (extrusion) or radially (turning).

3. Unary operations, such as copy, mirror, scale, stretch, rotate, and translate, are performed on one solid entity at a time.

4. Binary (Boolean) operations, such as union, intersection, and difference, involve any two solid entities.

5. Detailing and editing operations usually include blending (rounding of edges), filleting, and chamfering.

6. Viewing controls make several different types of display available to the user. Wireframe, wireframe with hidden lines removed, or shaded solids can be displayed at any user selected viewing angle. The user can also elect to have multiple viewing windows shown at once on the screen.

Given these basic operations, there will usually be a number of alternative approaches to constructing a model. One of the most obvious is the choice between Boolean operations and sweeping. The selection of procedures and the chosen sequence of operations definitely affects efficiency, and thereby the productivity associated with design using a solid modeling system.

Description of the Final Project

The final two weeks of the freshman EDG course are devoted primarily to a short design project. The objective of the project is to give the students a culminating experience in the use of solid modeling/CADD to build and provide documentation for an assembly of solid parts. A drawing of the caster (Fig. 1)[5] was provided to the students with a brief problem description. Submission requirements for the project included:

A shaded, colored, 3-D pictorial hardcopy of the finished assembly (either exploded or sectional).

A set of dimensioned 2-D orthographic production drawings of the assembly parts (view outlines to be created in AutoCAD using a DXF file transfer from the AutoSolid model).

Neatly sketched plans for the 2-D orthographic layout of assembly parts.

Neatly sketched plans of the solid modeling operations (unary, Boolean, sweeping, editing) used to construct the solid parts of the assembly. This could be precise CSG trees, sweep contour designs, or original schematic diagrams of the solid operations for each part.

Analysis of Student Procedural Approaches

The following analysis is based on fourteen group projects which were submitted during the Fall of 1989 and Spring of 1990. Each group usually consisted of three students. All final reports were examined carefully and all student procedural approaches toward each component of the assembly were noted.

The five different parts of the caster assembly are itemized below in order of complexity:

1. Support Pin
2. Collar
3. Wheel Shaft
4. Wheel
5. Wheel Frame

Due to the simplicity of the first three parts, almost all of the students used the same approach to modeling these compo-

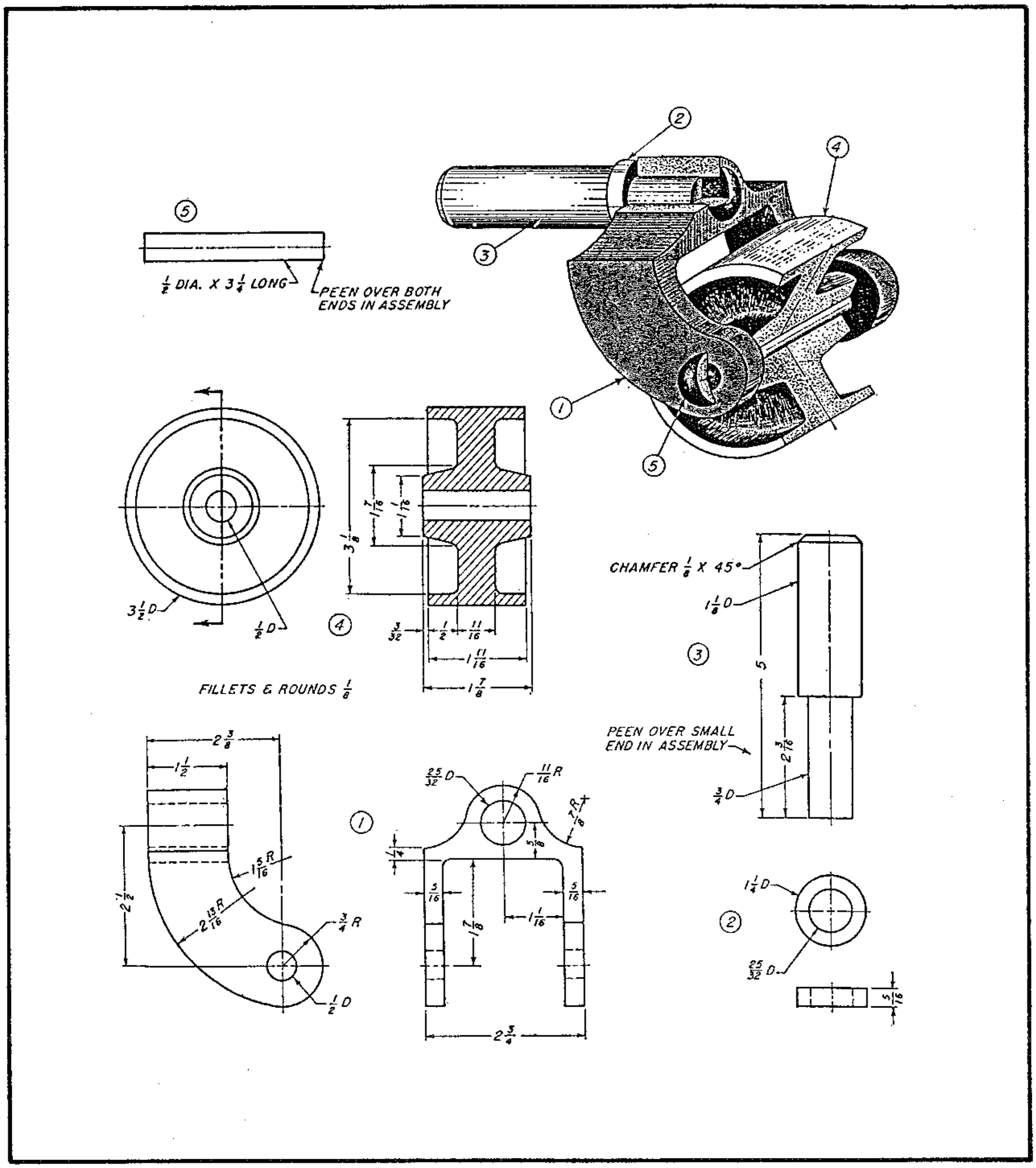

Fig. 1 Caster Assembly

nents. The support pin was, with one exception, created by invoking a cylinder primitive of the specified size and using unary operations (rotation and translation) to position it within the assembly (Fig. 2). There was likewise little variation in student approaches to construction of the collar. Thirteen of the groups created the collar using a Boolean difference of two cylinder primitives (Fig. 3). Only one group chose to create a profile in the sweep menu, then turn it 360 degrees about the Y-axis. (This group took the same approach with the support pin.) Two of the groups drew a profile of the wheel shaft in the AutoSolid sweep contour menu and revolved it 360 degrees (Fig. 4). The remainder of the students used a Boolean union of two cylinders and then applied the chamfer operation to the resulting part (Fig. 5).

Not surprisingly, all students chose to create a profile of the wheel and revolve it 360 degrees (Fig. 6). However, the groups were equally divided as to how they created the sweep contour. About half of the groups used the Sweep Contour menu in AutoSolid, and the remainder drew the profile with AutoCAD, then transferred it to AutoSolid.

The wheel frame offered the greatest diversity in procedural approaches. The students used five essentially different approaches for creating this part of the caster assembly. These have been designated as methods A through E in the figures. Method A, the most frequently used construction approach is illustrated in Fig. 7. Nine of the fourteen groups used this approach. The contour of the top of the wheel base frame was drawn in AutoCAD, transferred to AutoSolid, and extruded. A contour of the leg was drawn in AutoCAD, extruded in AutoSolid, and then duplicated. The three parts were then joined together with a Boolean union operation. The fillets were added with AutoSolid. (Fillet operations have been omitted from the figures in order to reduce the size and complexity of the drawings.) The only significant difference in the approach of these nine groups was in the creation

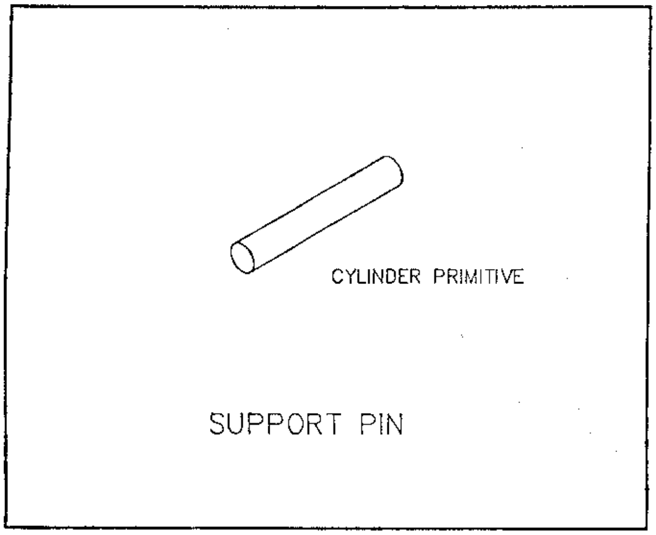

Fig. 2 Support Pin All groups except one invoked a cylinder primitive of appropriate dimensions.

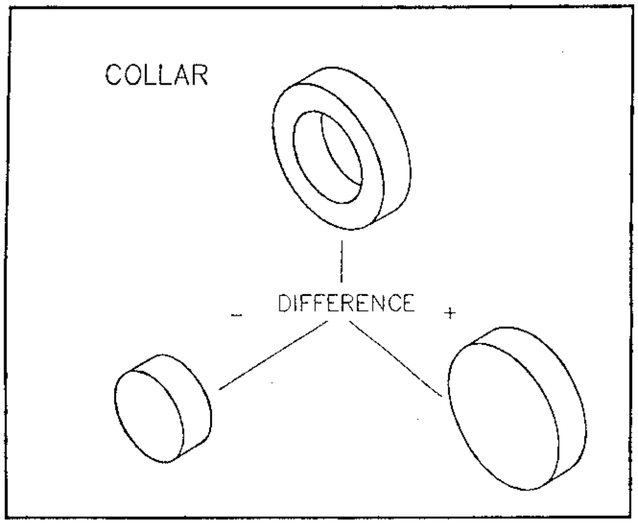

Fig. 3 Collar Thirteen groups used a Boolean appraoch. One group revolved a sweep contour.

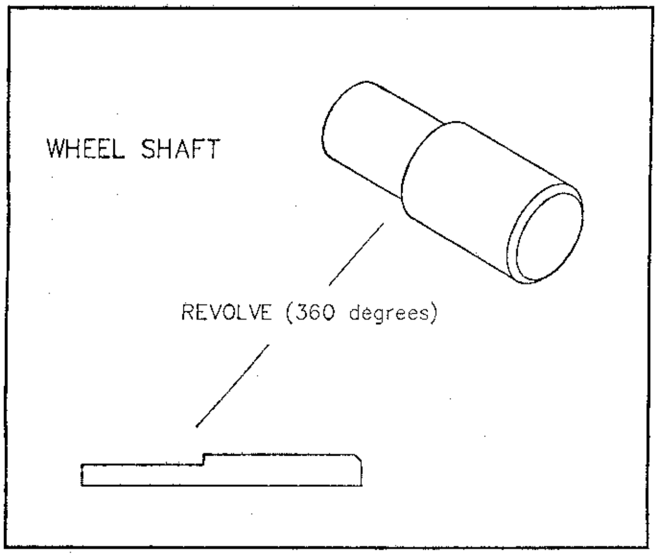

Fig. 4 Wheel Shaft Two student groups revolved a sweep contour.

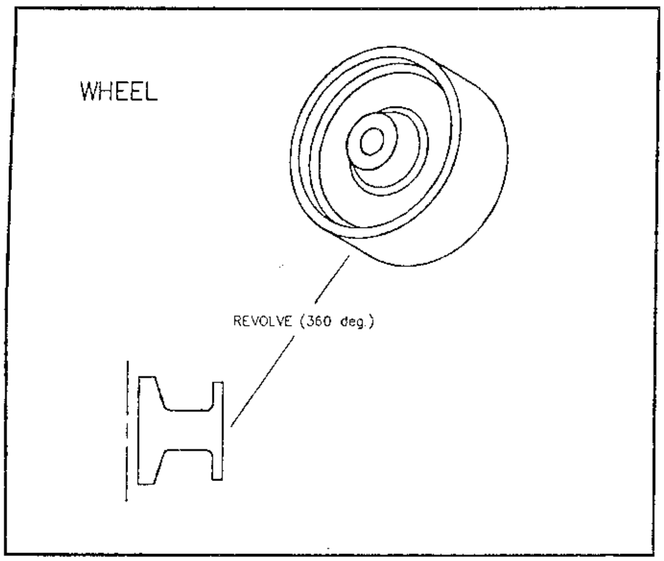

Fig. 6 Wheel All students used a sweep menu procedure.

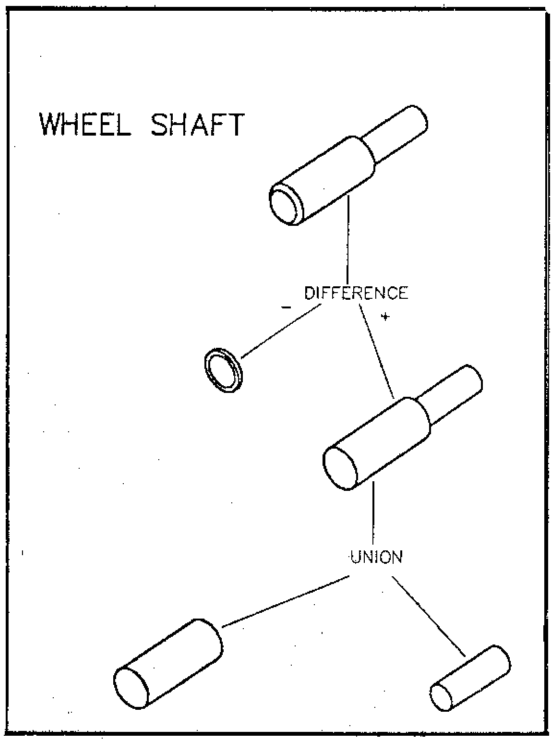

Fig. 5 Wheel Shaft Twelve of fourteen groups chose a Boolean approach.

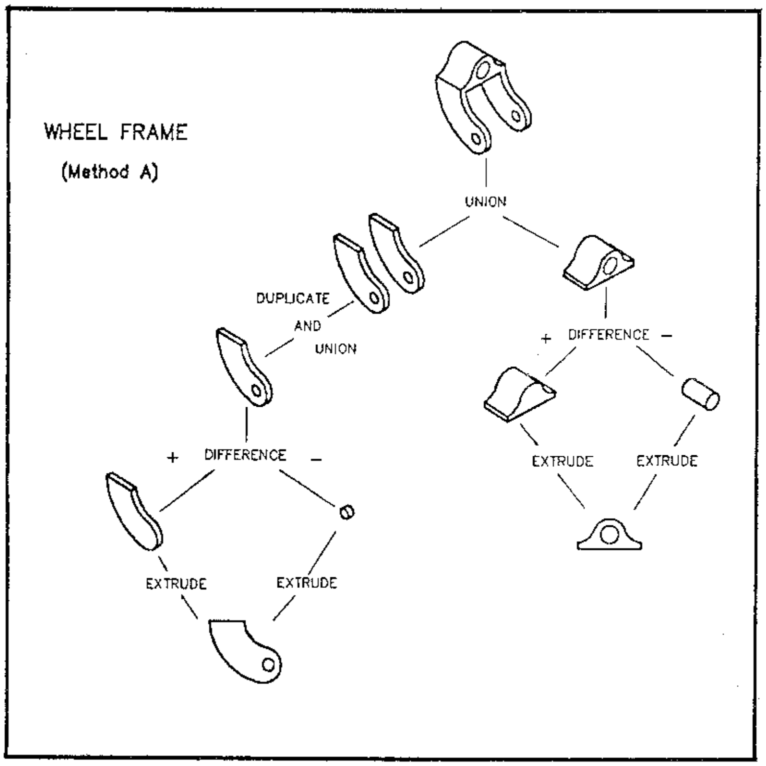

Fig. 7 Wheel Frame Method A was favored by most of the students. Nine of the groups used this approach.

of the hole. Five of the groups included the holes in the AutoCAD contours, extruded them in AutoSolid, and used a Boolean difference operation to create the holes (Fig. 7). The remaining four groups invoked a cylinder primitive to create the holes. Extruding the holes is a more efficient approach since it does not require additional steps to position the cylinder - the extruded hole is already in place. Method A was the most popular perhaps because it is the most intuitive. Students tend to separate an object into geometric components, build each of these, then combine them all with a Boolean union.

However, the most intuitive approach may not always be the most efficient. Although method B, which is illustrated in Fig. 8, is similar to method A, the two groups who chose method B were able to eliminate the duplication step by treating the legs as a single component. They extruded the leg contour the entire width of the wheel frame and then used a block primitive with a difference operation to remove the material between the sides. Both groups used a difference operation with primitive cylinders to produce the holes.

Only one group used Boolean operations to create the top of the wheel frame. A diagram of their approach is shown in Fig. 9. This approach was not popular because of the lack of tangency features in AutoSolid. It is not possible to automatically position a primitive cylinder tangent to the surfaces of existing solids in AutoSolid. Tangent points must be calculated mathematically. Therefore, this method requires more preliminary planning. Students' comments indicated that other groups tried this approach initially, but abandoned it in favor of extrusion in the Sweep Contour menu.

All of the groups used the Boolean union and difference operations quite frequently. Only method D involved an intersection operation. Figure 10 illustrates this approach. It is perhaps not the most intuitive approach, but it is clearly the most efficient in terms of the number of operations involved. The wheel frame was produced with an intersection of just two extruded contours. Since the holes were also extruded, positioning steps were kept to a minimum.

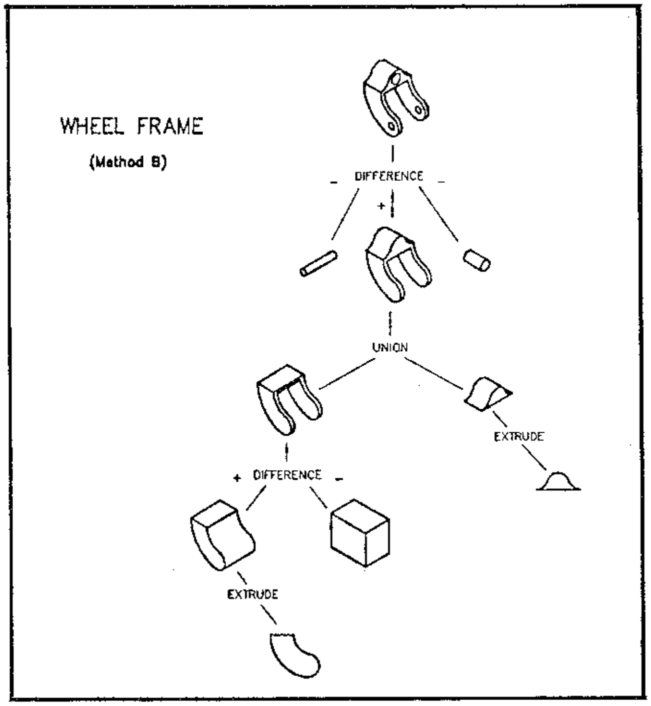

Fig. 8 Wheel Frame Method B, chosen by two student groups, differs from Method A in the way the legs were created.

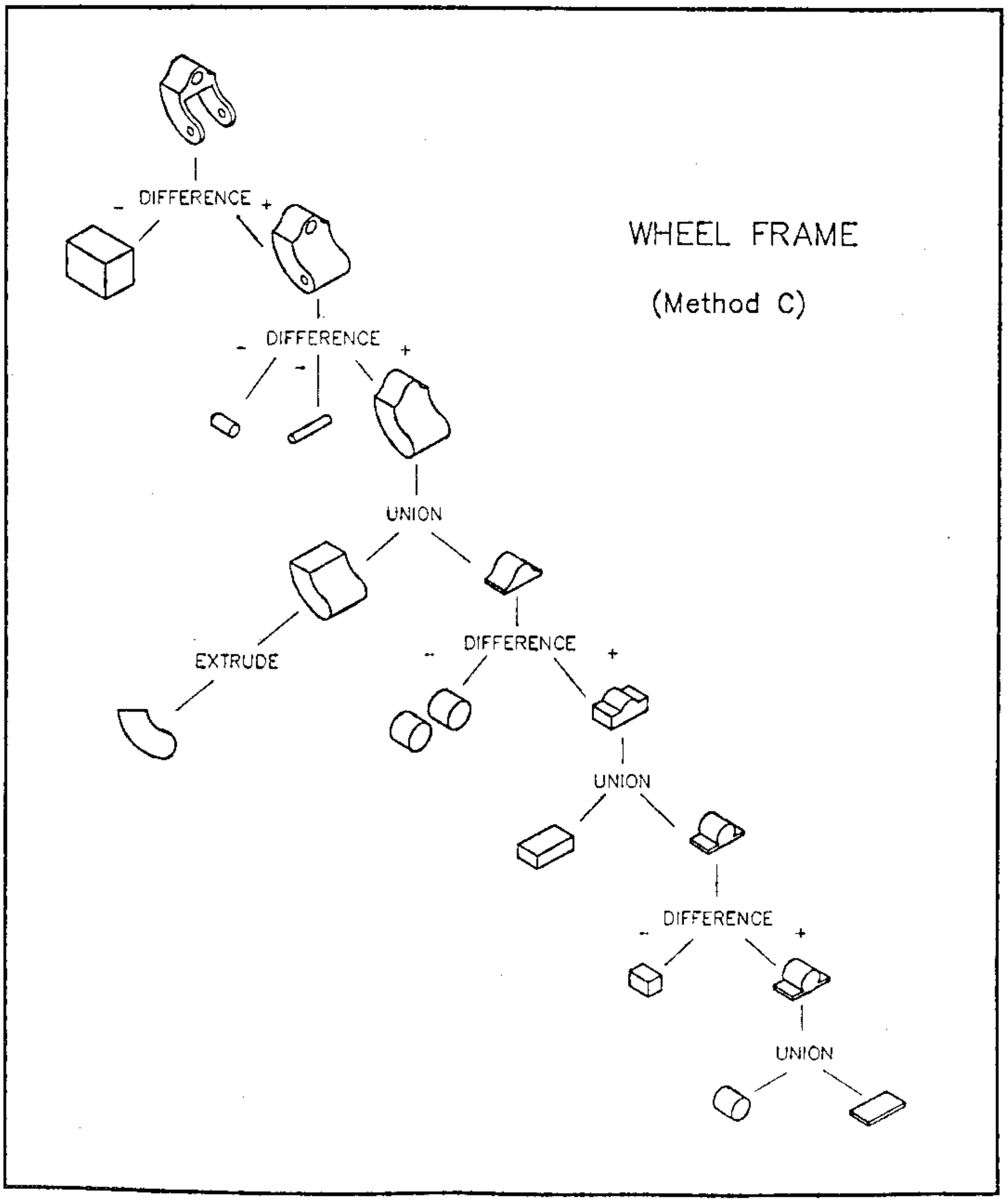

Fig. 9 Wheel Frame The Boolean approach was taken by only one group. It proved to be the least efficient in terms of construction time and file size.

The remaining group used a "machine shop" approach (Fig. 11). These students were apparently thinking in terms of milling a block when they generated and extruded a pattern for the top of the wheel frame. Then they used a difference operation to create the surface contour. The pattern was positioned by matching cutouts which served as "tool guides", or index marks. Although method E does not seem to have any significant advantage

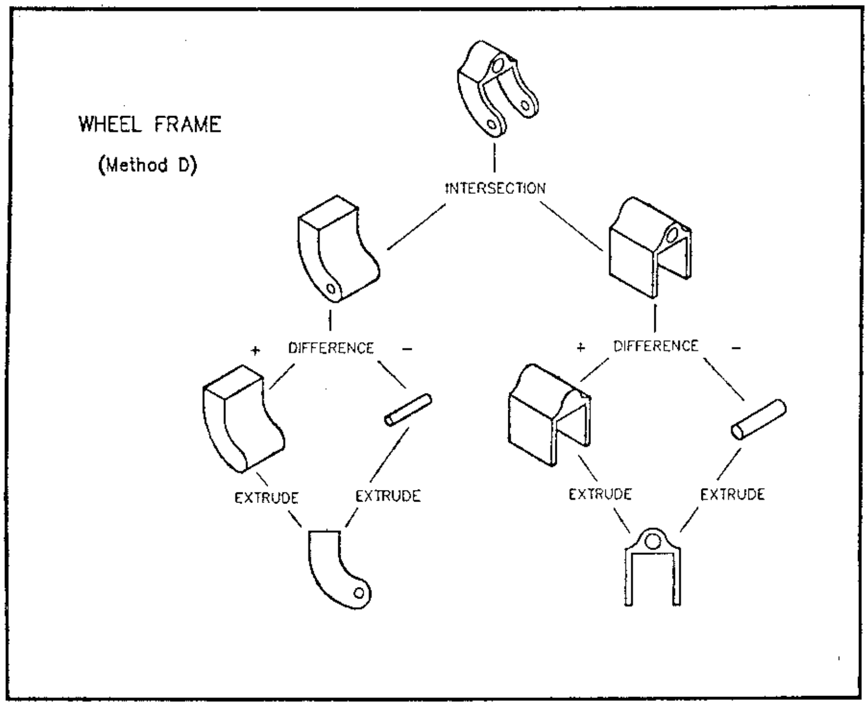

Fig. 10 <u>Wheel Frame</u> Only one group used an intersection operation to produce the part. Construction time and file size were minimized by this approach.

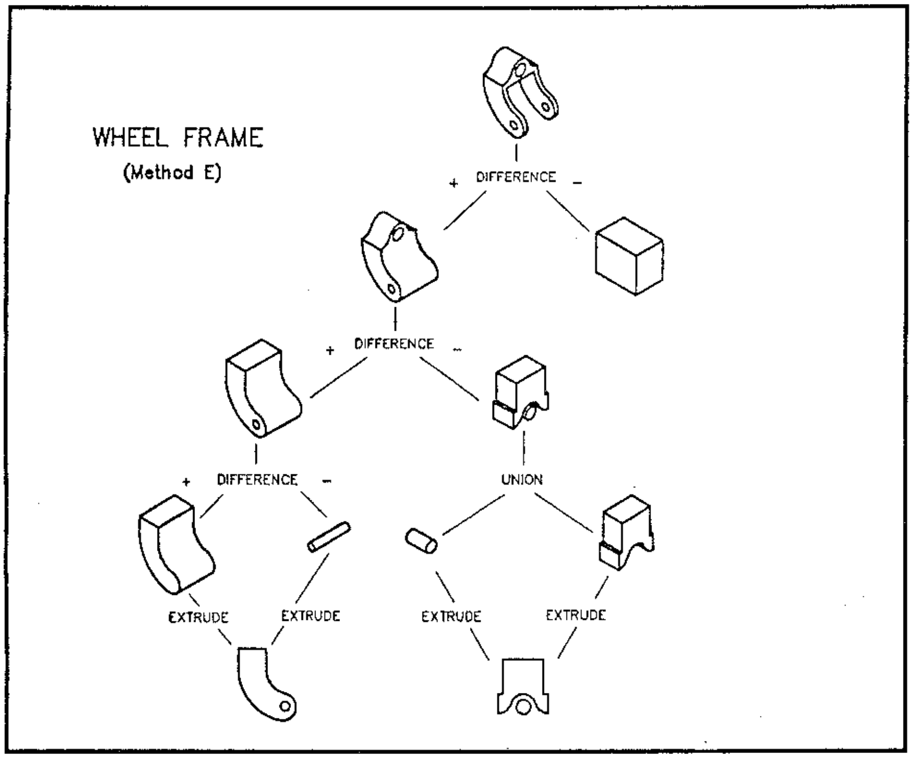

Fig. 11 <u>Wheel Frame</u> One group of students took a "machine shop" approach, using a pattern to create a surface contour.

over the other methods employed in this particular context, it does suggest a need for inclusion of some feature-based and machining operations in solid modeling systems.

The five procedural approaches for the wheel frame were evaluated in terms of effort (number of operations required to build the model), size of the CSG file, and time taken to display a boundary representation. A comparison of the five methods is shown in Fig. 12. It is apparent that the most frequently used approach did not minimize any of the three evaluation criteria. In fact, method D, the approach least likely to have been described or encouraged in the classroom, was the most efficient in terms of effort required and CSG file size.

Conclusion

Reduced effort (fewer operations required) in creating solid models will result in increased productivity. Therefore, it seems appropriate for instructors to encourage creative and efficient use of solid modeling systems in the examples given and exercises assigned. Based on the analysis of this single solid modeling exercise, the following

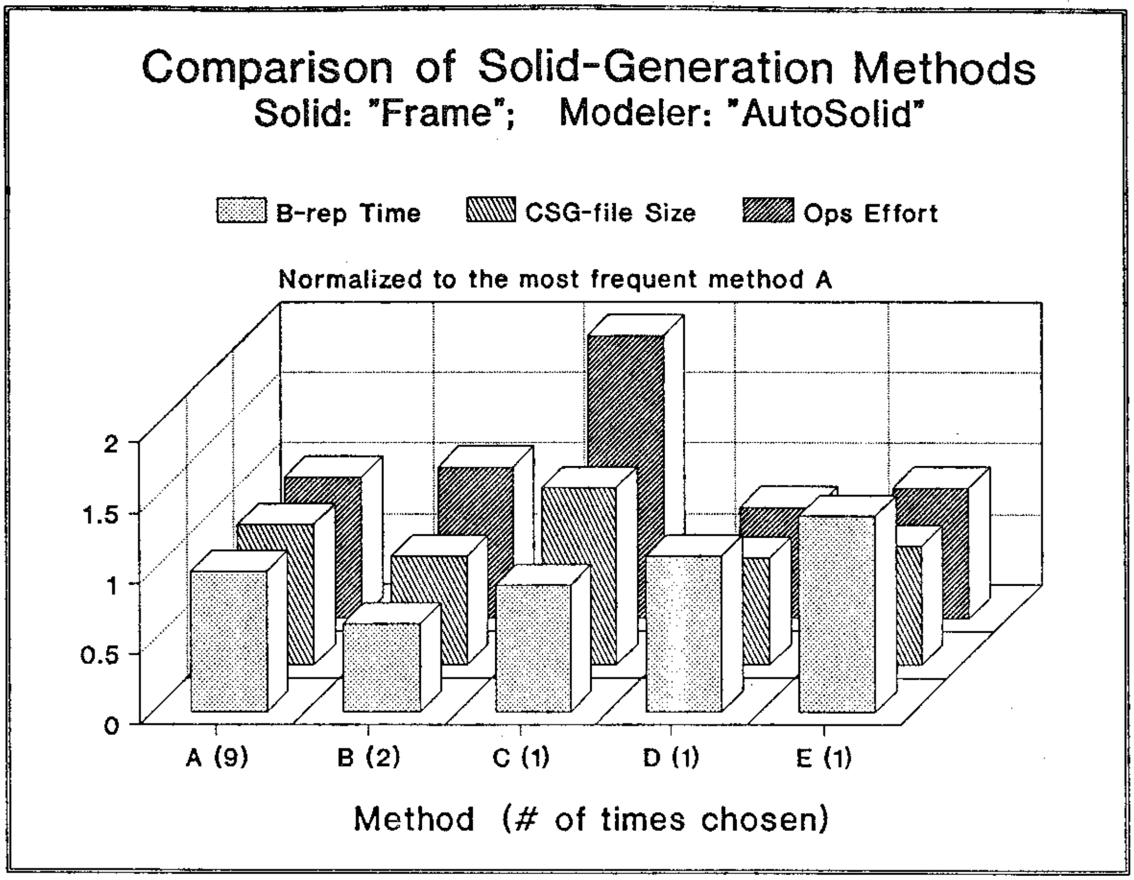

Fig. 12 A Comparison of Student Approaches to Building a Solid Model of the Wheel Frame

"rules of thumb" are suggested.

1. Although Boolean operations are necessary for joining and subtracting material, use of sweep contours might prove to be a more efficient approach toward building lower-order solids.

2. Contours with tangencies should be extruded or revolved when possible.

3. When extruding an outer contour, also extrude any inner contours, such as holes and slots. Although these features could be produced with geometric primitives, extrusion will eliminate the need for additional positioning operations later.

4. If two profiles are orthogonally related to each other in a solid mass, an extrusion in two orthogonal directions followed by a Boolean intersection may result in an extremely efficient way to create the model.

These and other similar suggestions need not, and really should not be presented to students as "law". They mainly serve to illustrate the diversity of approaches available in solid modeling and to encourage students to plan for greater efficiency and productivity.

This study indicates that solving solid modeling design problems is open-ended in terms of the approaches that can be used to obtain the same model as a final result. It appears that the main source of diversity is the choice between sweeping and Boolean operations. Faculty who wish to develop courses based on solid modeling need to be aware of this when planning student exercises and assignments.

This analysis of student approaches also indicates the fact that a solid modeling system requires a good 2-D CADD interface to be efficient. Lack of extensive tangency functions either in the AutoSolid sweep menu or in the Boolean menu dictates that many sweep contours must be drawn in the 2-D AutoCAD system and transferred to AutoSolid for extrusion. It also dictates the use of extrusion as opposed to Boolean operations in many cases, such as the wheel frame.

The solid modeling exercises and project completed by the students allow them to experience a modern approach to design where there is no unique problem solution and to realize how productivity can be impacted by design approaches. An early introduction to solid modeling techniques lays the foundation for continuing education in modern fundamentals of design, which are based on geometric modeling.

Acknowledgement

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Using 3D Geometric Models to Teach Spatial Geometry Concepts

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With the introduction of computers for design and graphic communications, the methods used to teach traditional topics, such as spatial geometry relations, have changed. Traditional descriptive geometry problems were solved using successive auxiliary views based on Mongean principles developed in the late 1700's. Using 3D models for design and communications requires new methods to solve traditional problems. Successive auxiliary views using projection techniques are no longer required to solve design problems. What is required is that the designer have a full understanding of geometric principles and be able to use the computer to solve problems. An explanation of 3D CAD usage to teach spatial geometry concepts using nontraditional techniques is given.

Introduction

Monge systematized all of drawing into a science he called la Geometrie Descriptive. This science had two goals: 1. preparing on uniform principles the working drawings necessary in the various arts, and 2. graphically solving problems in solid geometry[1]. No great advances in the science developed by Monge have been developed except for techniques used to simplify his methods[1]. Glass boxes, fold lines, and direct view are simply methods of presenting the graphic science developed by Monge.

Prior to Monge, in the 1600's, Descartes proved that analytic geometry could be used to solve problems. However, his methods were very tedious and time consuming. Monge's graphical procedures used to solve spatial problems were a significant development. Monge's methods proved to be much faster and very accurate when compared to using analytic calculations. Monge's methods were so revolutionary that they were classified as a military secret, preventing him from publishing his techniques until years later[2]. From 1795 to the present, Monge's techniques were modified but never abandoned.

Today it is possible to solve spatial problems using computers and three-dimensional CAD software. The computer serves as the analytical tool that can remove the tedium from calculations, the tool which Descartes lacked in the era preceding Monge. CAD can also remove some of the tedium and inaccuracies of creating multiple auxiliary views by projection or by using rotations to solve spatial geometry problems. With CAD it is possible to determine analytic solutions to spatial geometry problems and graphically view and document the results. The techniques to be described demonstrate how to solve spatial geometry drawings using two different CAD software products.

Using Traditional Methods to Solve Spatial Geometry Problems with CAD

When using a 2D CAD system the traditional methods of solving spatial problems, such as rotation or auxiliary views, can easily be transferred using the available software[3,4,5,6,7]. Programs can be created to automate the use of traditional methods to solve descriptive geometry problems, such as using AutoLISP with AutoCAD software[4]. Entirely new programs or software could be created to solve descriptive geometry problems using traditional methods[7]. Typically, these programs automate the solution of problems using what is termed "traditional techniques".

The problem does not lie in the use of 2D CAD to solve traditional spatial geometry problems. The problem with using traditional methods to solve spatial geometry problems lies with 3D CAD. Three dimensional CAD allows the user to create true 3D geometric models of figures. Even though the display of the 3D image is on a 2D screen, the model is represented as a 3D model in the computer's data base. This is significantly different from using 2D paper to represent 3D figures. It is now possible to represent 3D images as 3D data and project them onto a 2D media. The implication of this is significant and presents an entirely different set of parameters for the user and teacher of engineering graphics.

Most 3D CAD systems allow the user to manipulate 3D models by rotation or by creating a new view direction (auxiliary). The use of the words rotation and auxiliary should not be thought of in the same terms as used in traditional descriptive geometry. Computer rotation consists of rotating the entire 3D model in the current view. Obtaining a new view direction (auxiliary) when using computers consists of the creation of a new view point relative to the 3D model. There is no need to create lines of projection, fold lines, reference planes, or other aids to create a new view. The computer will automatically create the new auxiliary view after the view direction is defined. Various inquiry commands can be used to determine spatial geometric information, such as the true and projected lengths of lines, angles, diameters, etc. By manipulating the 3D computer model, it is possible to view lines and planes so that lines of sight are perpendicular or parallel to geometric entities. This allows the user to solve many spatial geometry problems using nontraditional methods.

The procedure developed to solve spatial geometry problems using 3D CAD is termed "space geometry"[8]. Space geometry is the science of graphic representation by which objects are manipulated in 3D space on computers for the purpose of solving problems relating to them. The theory of space geometry is based on traditional geometric principles, such as parallelism and perpendicularity, and has as a foundation orthographic projection, and plane and solid geometry.

Solving Space Geometry Problems with CADKEY, Version 3.5

CADKEY has successfully been used to teach space geometry principles. The block shown in Fig. 1 initiates a typical problem given to students. A three-dimensional geometric model of the part is created by the students. They are then asked to determine true lengths of lines and to obtain point views of oblique lines, edge and normal views of oblique planes, and angles between certain planes.

Fig. 2 is an isometric view of the block. CADKEY automatically creates this view and assigns it view number 7. The first step in determining the true length of oblique line C-G is to use the VIEW option to create a new view. The command sequence is shown at the top of the screen display (Fig. 2) as

DISPLAY VIEW NEW 3 PTS

The 3 PTS command prompts the user to choose the X axis for the new view. The X axis is defined by selecting the two endpoints of line C-G shown by the markers (X) in the figure. The order in which the endpoints are selected will not affect the answer but will change the visibility.

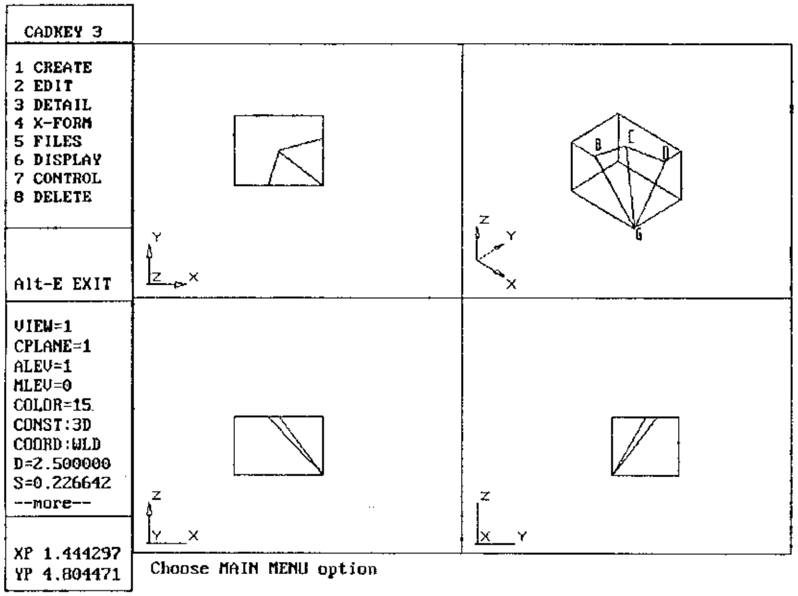
Another prompt requests the user to indicate the direction for the Y axis, as shown at the bottom of the screen (Fig. 2). Select the endpoint of line C-B or C-D. The new view is then displayed on the screen (Fig. 3). Students are then required to document their solution by adding labels, dimensioning the line, and using the software to query the length of the line. The CADKEY command sequence

CONTROL VERIFY COORD

is the sequence used to determine the true length of the line. Fig. 3 illustrates the querying command sequence at the top of the screen and the results at the bottom of the screen. When the actual and projected lengths of the line are equal, then the line is shown in true length in the current view.

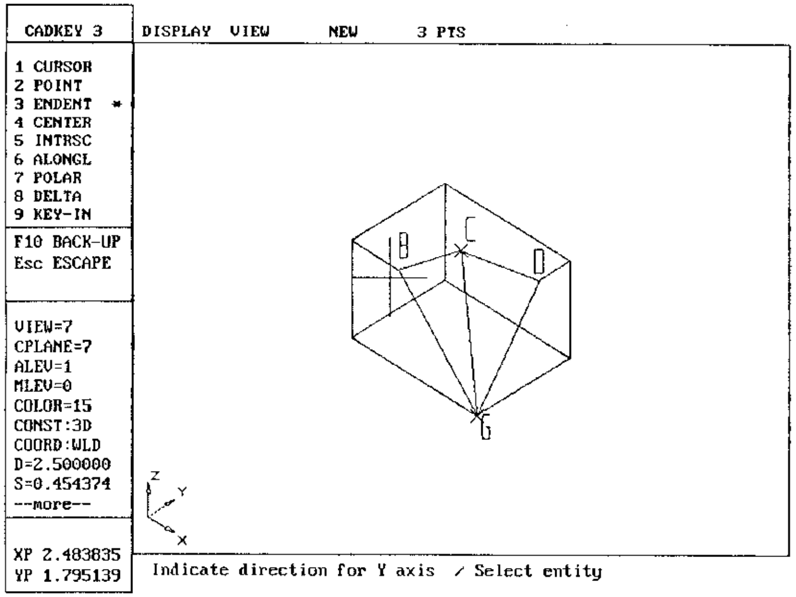
Line C-B was chosen as the Y display axis when the new view was created. This makes plane C-G-B normal in that CADKEY view. The steps used to find the normal view of an oblique plane with CADKEY are the same as finding the true length of a line in the plane. Using the

CONTROL VERIFY COORDS



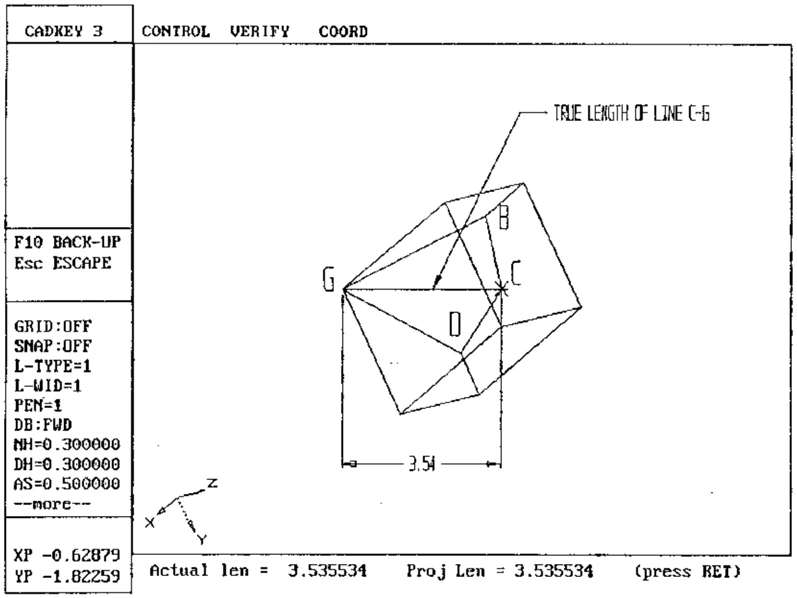
```
VIEW=1
CPLANE=1
ALEV=1
MLEV=0
COLOR=15
CONST:3D
COORD:WLD
D=2.500000
S=0.226642
--more--
XP 1.444297
YP 4.804471
Choose MAIN MENU option
```

Fig. 1



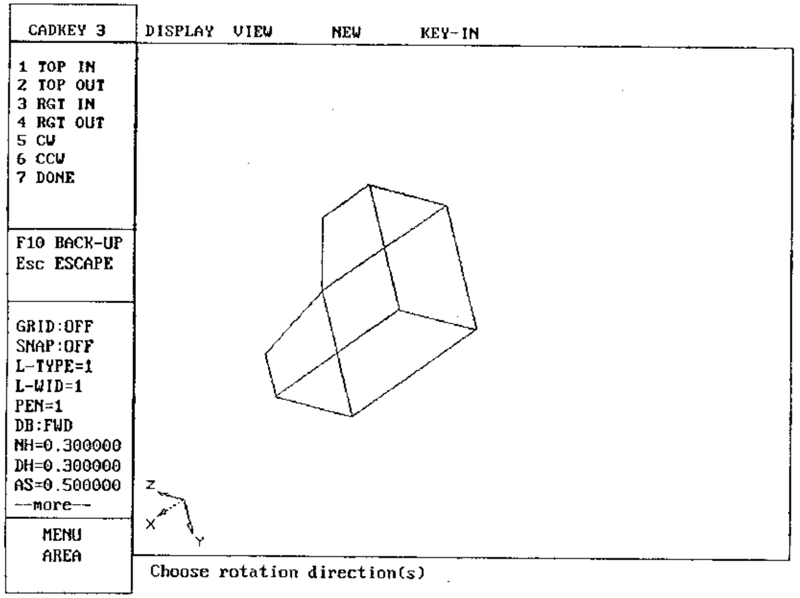
```
VIEW=7
CPLANE=7
ALEV=1
MLEV=0
COLOR=15
CONST:3D
COORD:WLD
D=2.500000
S=0.454374
--more--
XP 2.483835
YP 1.795139
Indicate direction for Y axis  / Select entity
```

Fig. 2



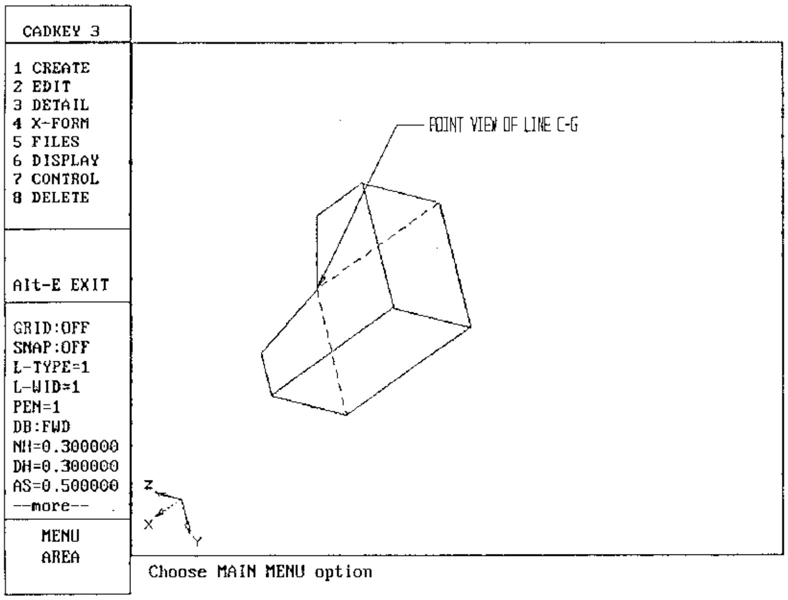
```
GRID:OFF
SNAP:OFF
L-TYPE=1
L-WID=1
PEN=1
DB:FWD
NH=0.300000
DH=0.300000
AS=0.500000
--more--
XP -0.62879
YP -1.82259
Actual len =  3.535534    Proj Len = 3.535534    (press RET)
```

Fig. 3



```
GRID:OFF
SNAP:OFF
L-TYPE=1
L-WID=1
PEN=1
DB:FWD
NH=0.300000
DH=0.300000
AS=0.500000
--more--
Choose rotation direction(s)
```

Fig. 4



GRID:OFF
SNAP:OFF
L-TYPE=1
L-WID=1
PEN=1
DB:FWD
NH=0.300000
DH=0.300000
AS=0.500000

Choose MAIN MENU option

Fig. 5

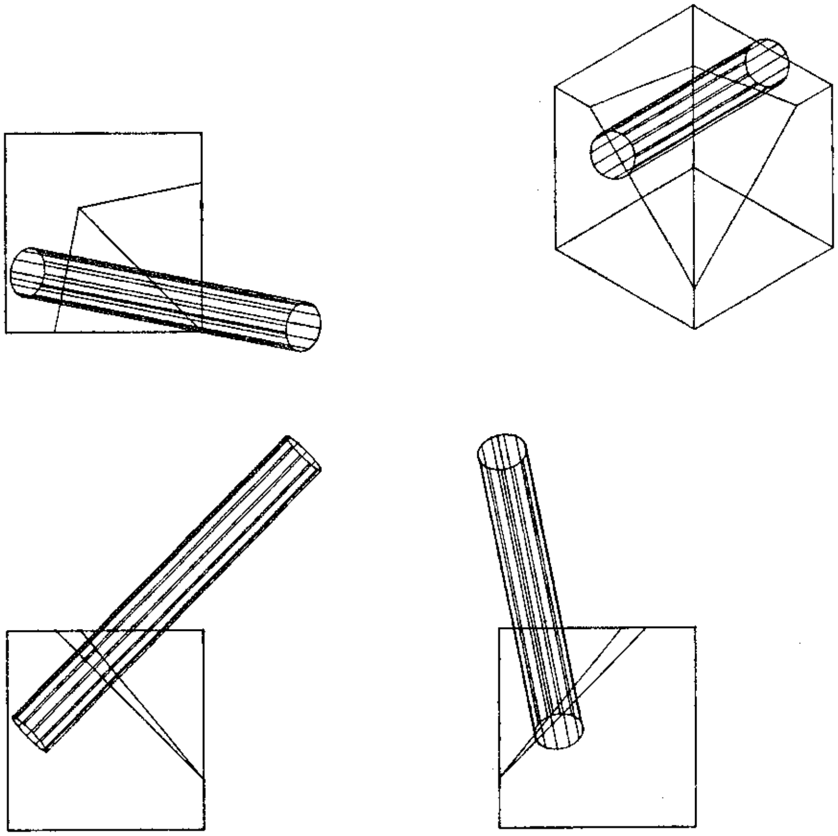


Fig. 6

option will verify that all the lines in plane C-G-B are true length in the current view.

The view rotation option of CADKEY is used to find the point view of the line C-G. The command sequence is

DISPLAY VIEW NEW KEY-IN RGT OUT

CADKEY prompts the user to enter the rotation angle, which for this example is 90 degrees. A new view is displayed (Fig. 4). Notice that this also creates edge views of the oblique planes. Fig. 5 illustrates the documentation required to complete the solution of the problem. The beauty of using 3D geometric models to solve spatial geometry problems is that for the first time it is possible to have analytic accuracy without tedious calculations and data entry.

Most of the traditional descriptive geometry topics are covered using CADKEY. Students are still required to solve the problems using hand tools and one of the traditional methods, such as fold line or direct view. The final problem assigned requires the student to apply what has been learned. Fig. 6 illustrates the solution to a problem which requires them to insert a shaft of a specified diameter through the center of an oblique plane at a specified angle using CAD.

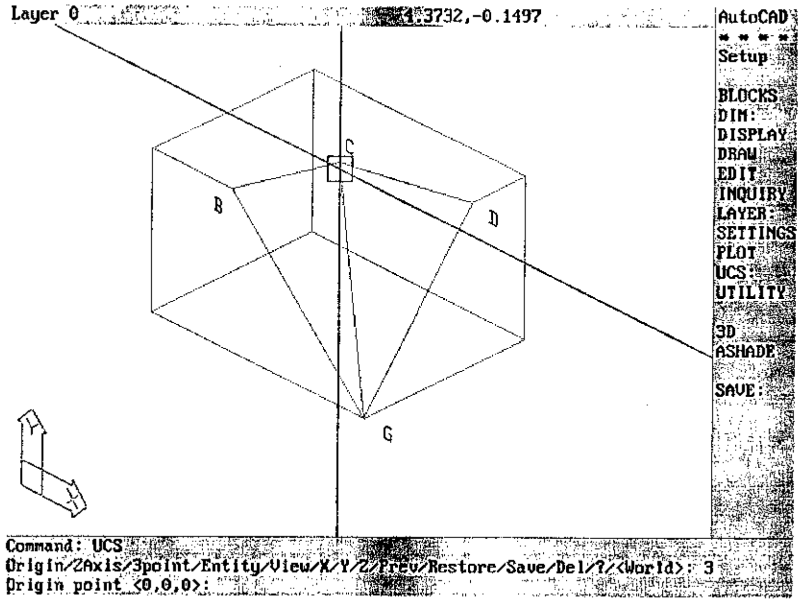
Solving Space Geometry Problems Using AutoCAD, Version 10

AutoCAD can also be used to solve spatial geometry problems. The same block used with CADKEY is used to demonstrate the use of AutoCAD, Version 10. The three-dimensional block can be created as a wireframe or surface model. The advantage of using the surface model is that the hide command can be used to automatically determine visibility.

Before solving the spatial geometry problem, create an axonometric view of the part using the VPOINT command. Turn the UCS (user coordinate system) icon on by using the UCSICON command, then set the OSNAP to ENDpoint. The technique used to solve the spatial geometry problem with AutoCAD is to change the UCS's position in 3D space, then create a new view perpendicular to the new UCS position. The AutoCAD UCS is synonymous to a construction plane.

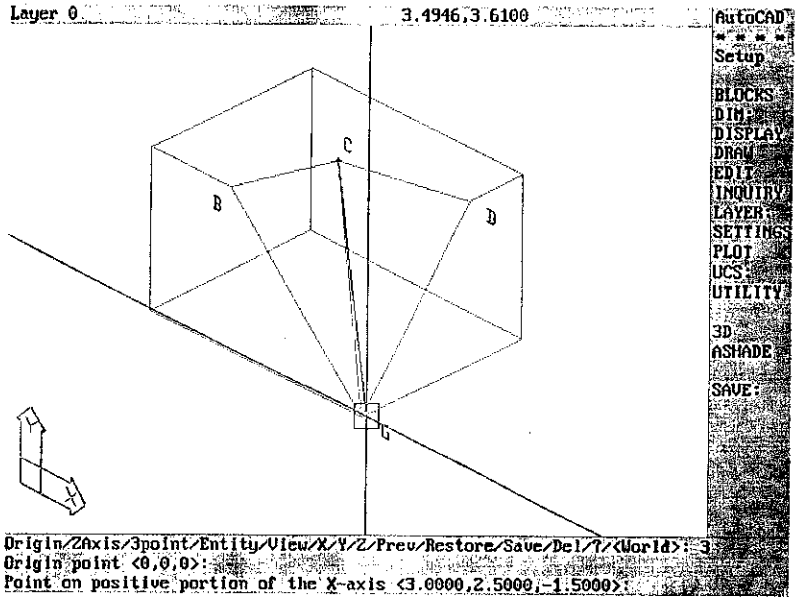
The first step used to determine the true length of oblique line C-G is to enter UCS at the AutoCAD command prompt. The 3 Point option is selected by entering 3 at the prompt. Move the aperture target over point C on the 3D model and select it to define the origin of the UCS (Fig. 7). Move the aperture target over point G and select it to define the positive direction for the X-axis of the UCS (Fig. 8) Move the aperture over point D and select it to define the Y-axis of the UCS (Fig. 9). The UCS icon and construction plane are now in plane C-D-G (Fig. 10).

It is now possible to create a new view which will be perpendicular to line C-G by using the DISPLAY option, PLAN. At the command prompt enter DISPLAY and select PLAN and then CURRENT.



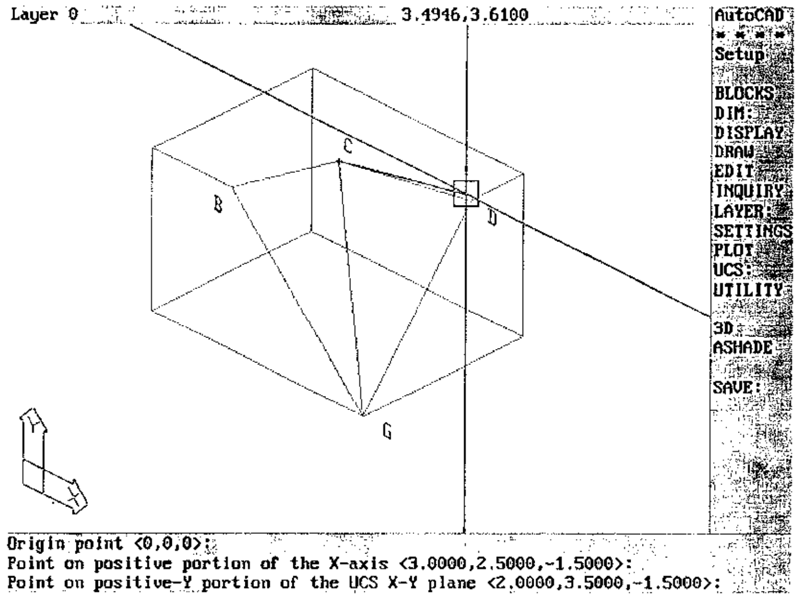
```
Command: UCS
Origin/ZAxis/3point/Entity/View/X/Y/Z/Prev/Restore/Save/Del/?/<World>: 3
Origin point <0,0,0>:
```

Fig. 7



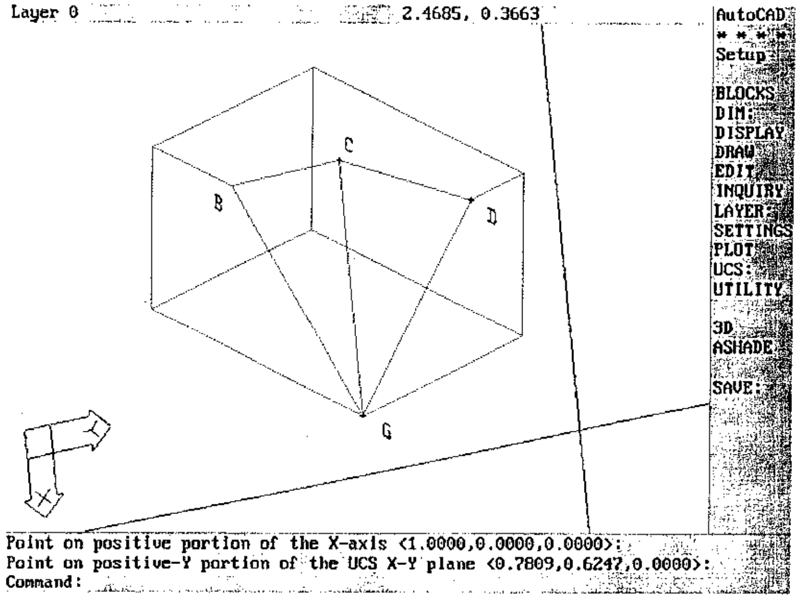
```
Origin/ZAxis/3point/Entity/View/X/Y/Z/Prev/Restore/Save/Del/?/<World>: 3
Origin point <0,0,0>:
Point on positive portion of the X-axis <3.0000,2.5000,-1.5000>:
```

Fig. 8



```
Origin point <0,0,0>:
Point on positive portion of the X-axis <3.0000,2.5000,-1.5000>:
Point on positive-Y portion of the UCS X-Y plane <2.0000,3.5000,-1.5000>:
```

Fig. 9



```
Point on positive portion of the X-axis <1.0000,0.0000,0.0000>:
Point on positive-Y portion of the UCS X-Y plane <0.7809,0.6247,0.0000>:
Command:
```

Fig. 10

The PLAN view option will create a view perpendicular to the current UCS which is perpendicular to line C-G (Fig. 11).

The true length of line C-G is determined by entering INQUIRY from the command prompt. The DIST (distance) option is selected and points C and G are picked with the cursor. The distance or length of the line is displayed in the prompt line (3.5355) at the bottom of the screen (Fig. 11). To verify that the line is true length in the current view, the angle from the X-Y plane must be equal to zero. The prompt line in Fig. 11 displays the angle from the X-Y plane as being equal to zero, so the line C-G must be true length in the current AutoCAD view. Each line in plane C-D-G could be verified using the INQUIRY-DIST command.

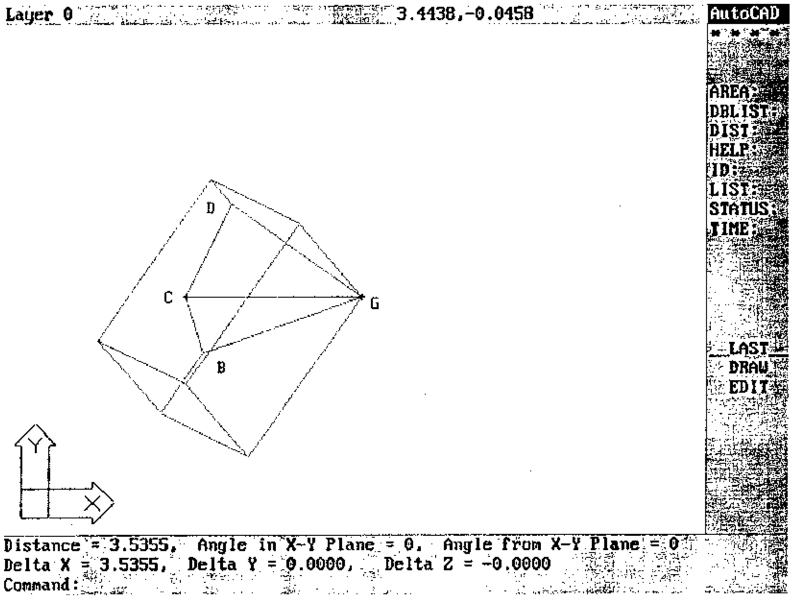
To find the point view of line C-G, rotate the current UCS 90 degrees about the Y-axis. Enter UCS from the command prompt and select the Y option by entering it from the keyboard. Enter 90 degrees for the rotation angle. The UCS icon in the lower-left corner changes to a broken pencil, which indicates that the X and Y axes are on edge in the current view. To view line C-G as a point, enter DISPLAY at the command prompt, then enter PLAN, and finally enter CURRENT. A new view showing the point view of line C-G is automatically displayed (Fig. 12). The angle between the planes can be measured in this view using the DIM (Dimension) command and the ANGLE option. To determine visibility of the new view, select the DRAW command and the 3D FACE option and pick three points on the base of the block to create a surface. Enter HIDE at the command prompt to automatically determine the visibility of the view (Fig. 13).

Discussion

Of course, it is possible to use the inquiry command of the software to determine the true length of any oblique line in a 3D model without changing views. However, there is a real value in having students solve spatial geometry problems using CAD. Manipulating the graphic representation of the 3D geometric data base to create new views can be applied to real engineering problems encountered when designing with CAD.

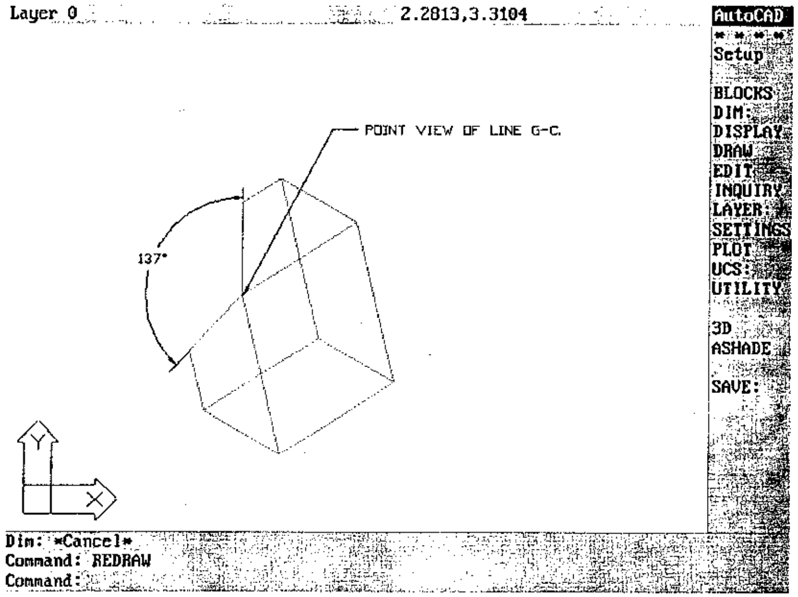
It is recognized that the most effective methods of using CADKEY and AutoCAD to solve spatial geometry problems may not have been used for finding the true length and point view of line C-G. More work must be done to try different procedures and other classic examples of spatial geometry problems using concepts introduced here. What has been demonstrated is that it is possible to use the strengths of the computer to solve spatial geometry problems using nontraditional techniques.

Using CAD for space geometry problems raises some interesting pedagogical questions. If space geometry problems can be solved on computers using nontraditional methods, of what importance is spatial geometry in a modern engineering graphics curriculum? Glass boxes, fold lines, and direct view methods



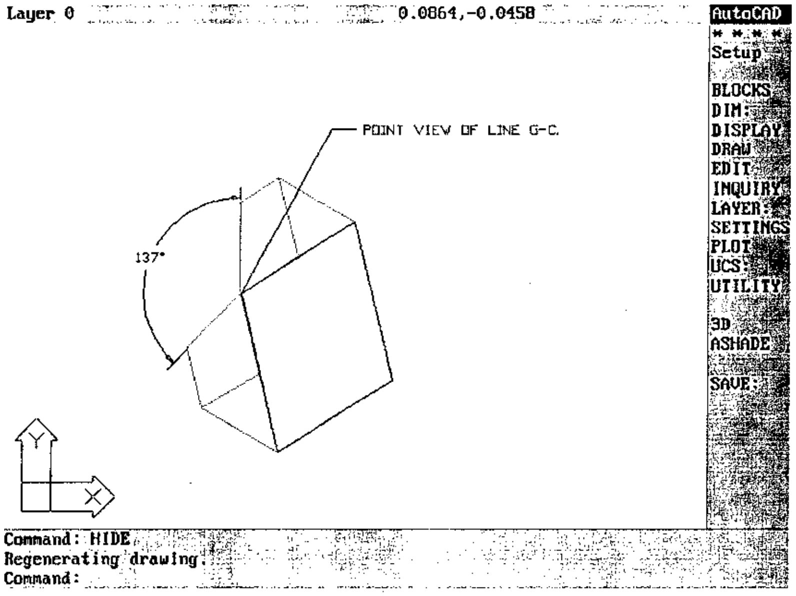
```
Distance = 3.5355,  Angle in X-Y Plane = 0,  Angle from X-Y Plane = 0
Delta X = 3.5355,  Delta Y = 0.0000,   Delta Z = -0.0000
Command:
```

Fig. 11



```
Dim: *Cancel*
Command: REDRAW
Command:
```

Fig. 12



```
Command: HIDE
Regenerating drawing.
Command:
```

Fig. 13

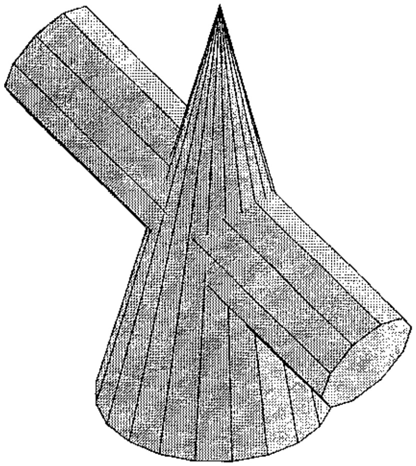


Fig. 14

are nothing more than methods of solving and teaching Mongean geometry principles. There is nothing sacred about any of these methods when it comes to 3D CAD. What is important is the underlying principles of spatial geometry. Fig. 14 illustrates the solution for the intersection of a cone and cylinder using solid modeling. The solution for this problem was created in a relatively short time when compared to using traditional tools and techniques. How will solid modeling affect traditional topics, such as intersections and developments?

Could it be that an era has come to a close? The era of using traditional techniques for the solution of spatial geometry problems that began with Monge and has now ended with the application of 3D CAD. Could it be that the use of analytic geometry using 3D CAD to solve spatial geometry problems has come to the forefront again? Two-dimensional CAD can be used to solve spatial geometry problems using traditional methods but for what purpose does that serve? With 3D CAD it is possible to determine the analytical solution to spatial geometry problems using a graphical interface. This offers the designer the best of both worlds.

Conclusions

There are an infinite number of views that can be created of a line, plane, or solid geometric model. However, there are some that are more important than others when designing and analyzing. Creating views where the lines of sight are parallel or perpendicular to lines and planes is important for design, whether using paper or CAD. For example, to construct a hole perpendicular to a surface with CAD, a view must be found or a construction plane must be created perpendicular to the surface initially. How this is done with a particular CAD system is not the primary concern of the engineering graphics instructor. What is important is to provide the student with a graphical method to solve problems and to teach the underlying geometric concepts.

Some in the profession have forgotten that instructors should be teaching concepts and not skills. Glass boxes, fold lines, and direct views are methods used to solve problems graphically. The underlying geometric principles are the important concepts and form the core subject matter of engineering graphics. These principles can then be used by the student and applied to any geometric problem using any software. At a time when the engineering graphics curriculum is overflowing with material to cover in too short a time, the methods described here to solve spatial geometry problems and teach basic geometric principles can be used to replace or supplement traditional techniques. By using 3D CAD to teach spatial geometry concepts, it is possible to teach more subject matter in less time.

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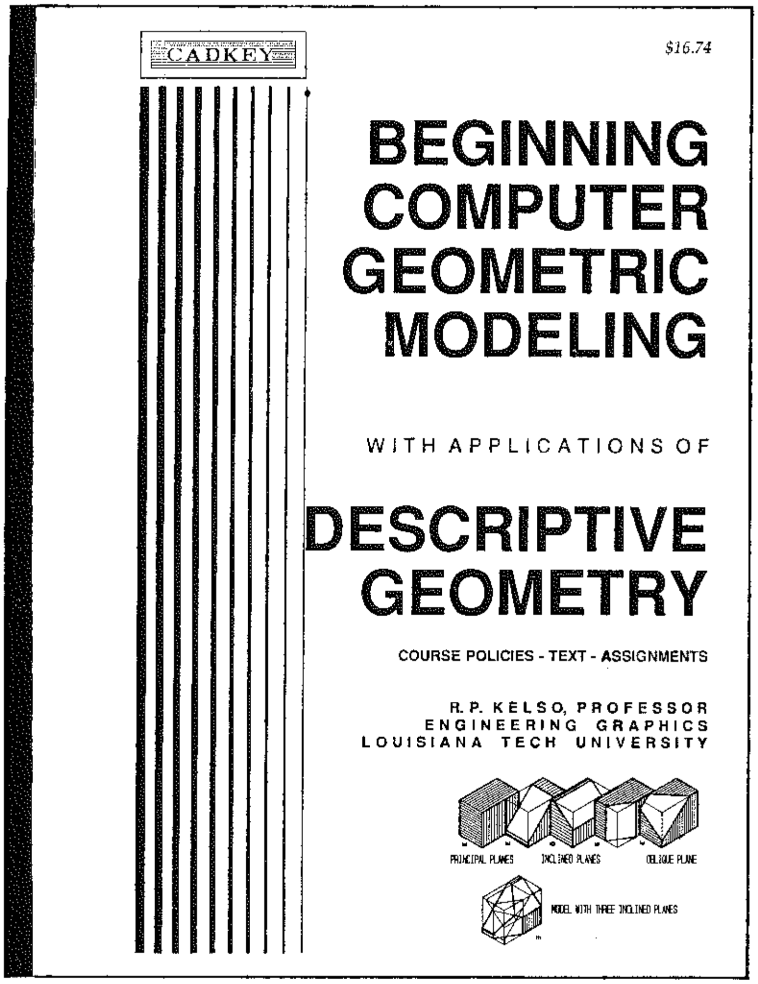

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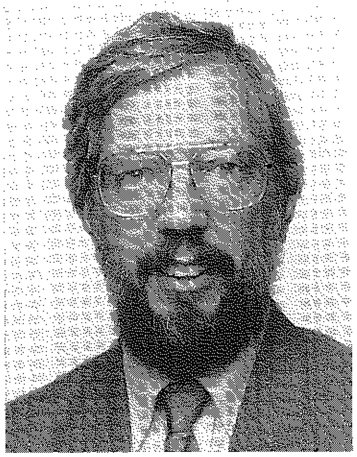
Tenure-track position available for Fall, 1991 in Manufacturing Technology to teach courses in CAD and technical drawing. Specific courses could include introductory graphics, computer-aided design (introduction through solids modeling, advanced technical drawing). The ability to teach in a related area of manufacturing is highly desirable for this position. Minimum Qualifications: Masters degree in one of the following: 1) engineering or engineering technology, 2) a related field which is primarily analytical (physics, mathematics), or 3) other technical field if professionally registered; at least three years of recent industrial experience in a competitive manufacturing environment. Preferred Qualifications: Professional engineering registration, a doctoral degree in an area related to manufacturing, substantial industrial experience, and a record of successful teaching in engineering technology. Applicants are expected to pursue curriculum development and publication in areas related to their teaching speciality. Rank and salary are open and dependent upon educational level and experience. Send a letter of application summarizing minimum and preferred qualifications for this position, a resume, three original, current letters of recommendation for this position, and an official transcript(s) of all college credits to: Dr. Wesley L. Baldwin, Chairperson, Graphics Search Committee, Department of Industry and Technology, Ball State University, Muncie, IN 47306-0255. Telephone: (317) 285-5662 or 5641. Review of applications will begin March 1, 1991 and continue until the position is filled.

Ball State University Practices Equal Opportunity in Education and Employment

Chairman's Message

by

Jon Jensen



Not available at press time

1893 ASEE 1993

SHAPING OUR WORLD – CENTURY II

Nominees for Division Officers

by
Rollie Jenison

The following persons have been nominated for the positions indicated. Ballots will be mailed in February.

Vice-Chairman (1991-92)

VERA ANAND

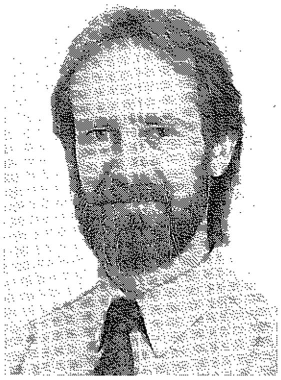
Vera is an Associate Professor of Engineering Graphics and Coordinator for the Engineering Graphics Program at Clemson. She earned her undergraduate degree at the University of Brazil and her graduate degree at Northwestern University, all in civil engineering. Vera has been actively involved with the EDGD, having served as chairman for the 1985 Annual Conference, chairman of the International Relations Committee and Director: Professional and Technical Committees. In addition, she has moderated sessions and made presentations at EDGD meetings. She has authored several papers on engineering/computer graphics appearing in various journals and has conducted workshops on the use of computer graphics in undergraduate engineering design funded by the NSF.

JERRY SMITH

Jerry is Professor and Department Head of Technical Graphics at Purdue and has been responsible for the development and coordination of numerous courses. He was instrumental in the research, selection, and purchase of the graphics equipment for the new Knoy Hall of Technology. He has coauthored two text/workbooks for CADD software packages and has given numerous presentations at various conferences. He is a member of the American Design Drafting Assoc. (ADDA), the National Computer Graphics Assoc. (NCGA), and the Computer and Automated Systems Assoc (CASA) of the Society of Manufacturing Engineers (SME). Since 1982 Jerry served the EDGD as Program Director for the 1984 mid-year conference and as Advertising Manager of the *EDG Journal*.

Secretary–Treasurer (1991–94)

JIM LEACH



Jim is an assistant professor at the University of Louisville Speed Scientific School and Director of the Authorized AutoCAD Training Center. He holds the Bachelor of Industrial Design and Master of Education degrees from Auburn University. Before teaching at the University of Louisville, Jim worked as an industrial designer for three years and then taught engineering graphics for 13 years at Auburn University. As coordinator of engineering graphics at Auburn, Jim is credited with developing the CADD labs and courses. As an ASEE/EDGD member since 1984, he has served as Director of Liaison Committees, member of the EDG Journal Board of Review, and presenter and moderator at several conferences. Other professional activities include several journal articles and workbooks.

MIKE MILLER

Mike is an Assistant Professor of Engineering Graphics at The Ohio State University. He received his B.S. in Industrial Engineering from the University of Michigan and an M.B.A. from The Ohio State University. He joined the Engineering Graphics Department in the Autumn of 1985. Prior to that time he was Sponsored Program Development Officer for the College of Engineering and Associate Director of the Engineering Experiment Station. In 1980 and 1981 he taught and assisted in the development of a new engineering graphics course sequence combining FORTRAN programming, conventional graphics instruction, and computer graphics programming. He is coauthor of *Engineering Graphics* and *Introduction to Computer Graphics*. He is author of educational computer aided drawing programs "GraphiCAD" and "FIRSTDRAW".

Director: Publications (1991-94)

DEL BOWERS

Del is an Associate Professor of Interactive Computer Graphics and Coordinator of Freshman Engineering Graphics at Arizona State University. He has been a member of ASEE since 1983. Recent professional activities include presentation of papers at national and regional conferences, journal articles, and contributions to workbooks and textbooks. Ongoing research activities include investigation of teaching methods to improve visualization and creativity. Del served as Facilities Chairman for the most recent Mid-year EDGD Conference held in Tempe, Arizona in November, 1990.

MARY SADOWSKI

Mary is an Associate Professor of Technical Graphics in the School of Technology at Purdue. She received her B.S. at Bowling Green State University in Ohio, her M.A. from The Ohio State University, and her Ph.D. from Purdue. She has taught graphics at all levels of education, including elementary, secondary, and university classes. At Purdue her activities include teaching graphics, desktop publishing, and instructional and curriculum design. Recently she has been actively involved in the development of a four-year Purdue Technical Graphics Program.

Mary has been an active presenter at ASEE/EDGD and NSPI (National Society for Performance and Instruction) conferences for the past seven years. She has written and presented, especially in the area of creative thinking and desktop publishing.

Mary is currently concluding a Delphi Survey as part of an ACM-SIGGRAPH grant which is concerned with the development of a curriculum model for engineering graphics.

Calendar of Events

by
Bill Ross

1991 ASEE Annual Conference
    June 16-20, 1991
    New Orleans, Louisiana
    Theme: Challenges of a Changing World
    Program Chair: Bill Ross
        Purdue University
        Ph. (317) 494-8069
        FAX (317) 494-0486
    Facilities Chair: Mary Jasper
        Mississippi State Univ.
        (601) 325-3922

1991-92 EDGD Mid-year Conference
    November 3-5, 1991
    Norfolk, Virginia
    Host: Old Dominion Univ.
    Gen. Chair: Moustafa Moustafa
        Old Dominion Univ.
        (804) 683-3767
    Prog. Chair: Barry Crittenden
        VPI&SU
        (703) 231-6555

1992 ASEE Annual Conference
    Toledo, Ohio

1992 5th International Conference on Engineering and Descriptive Geometry
    August 17-21, 1992
    Melbourne, Australia
    Contact: Larry Goss
        Engineering Technology
        Univ. of Southern Indiana
        8600 University Blvd.
        Evansville, IN 47712

1992-93 EDGD Mid-year Conference
    San Francisco, California
    (tentative)

1993 ASEE Annual Conference
    Urbana, Illinois

1991 ASEE Annual Conference

New Orleans, Louisiana

by
Bill Ross and Mary Jasper

Come experience the "Big Easy". Welcome to New Orleans, one of the most charming and fascinating cities in the United States. From its French origins in 1718, New Orleans has developed uniquely through a rich blend of cultures - European, African, and Caribbean. Bring a healthy appetite for the city abounds with all varieties of restaurants and New Orleans is world famous for its unique spicy seafood dishes and Cajun cooking. And, to sooth or liven your soul, live jazz music is played in numerous locations in the world famous French Quarter; a 10-12 minute walk from the conference center.

The Hyatt Regency, which is adjacent to the Louisiana Superdome, will serve as headquarters for the conference; including exhibits, displays, and most major functions. Conference activities and sessions will also take place at the Hotel Inter-Continental, approximately a 7-9 minute walk from the Hyatt. Additional information on lodging, parking, and transportation will be mailed to you in the conference registration package.

Meals at official meetings will be standardized within each hotel, i.e., all Tuesday dinners at the Hyatt Regency will have the same menu. Shrimp Provencale, New Orleans style, has been requested for the Division Banquet on Tuesday night. This will allow ASEE to negotiate a single blanket guarantee for numbers of people and will help reduce the cost of official meals. Other than for official functions, hotel food costs, as in most major city hotels, are expensive. However, attached to the Hyatt Regency and connecting it to the Superdome is a 150 store mall with a variety of shops and stores. Additionally, prices for food and entertainment in the French Quarter are very reasonable.

The weather in new Orleans in late June is comparable to a sauna bath. Daily temperatures may be in the high 90's with a relative humidity index of "wet". Dress comfortably, cooly, and bring plenty of light clothes. A 10-minute walk on a hot, sunny, and humid New Orleans' summer day could easily create the need for an extra change of clothing. Out of necessity, this should be one of the most casual conferences ever.

Our program is firm. We have six technical sessions directly involving our members, an Executive Committee meeting, our awards banquet, and the business luncheon meeting in our schedule. Sessions sponsored or co-sponsored by the EDGD which include involvement or presentations by our members include:

1238 - Mon., 6/17, 8:30-10:15 am
Visualization & Research I
Sponsor: EDGD
Co-Sponsor: Design in Engineering Education Division & SIGGRAPH
Moderator: Carol Hoffman, University of Alabama

Research in and methods of developing visualization abilities for engineering students are presented, both with traditional and new techniques. Some statistical studies of performance on visualization tests are also presented. This is the first of two related sessions.

1438 - Mon., 6/17, 12:30-2:30 pm
Visualization & Research II
Sponsor: EDGD
Co-Sponsor: Design in Engineering Education Division & SIGGRAPH
Moderator: Ed Galbraith, California State Poly. Univ.
(See session 1238)

1638 - Mon., 6/17, 4:30-6:00 pm
EDGD Executive Committee Meeting
Moderator: Jon K. Jensen, Marquette University

Business meeting of the officers and directors. Open to members of the Division by invitation.

1838 - Mon., 6/17, 8:00-10:00 pm
Developing a Curriculum Paradigm for Engineering Design Graphics
Moderator: Gary R. Bertoline, Purdue University

An open forum discussion concerning the development of a paradigm defining the underlying body of knowledge, a standardized taxonomy, professionally recognized areas of research, and other areas sufficient to describe the scholarly range of engineering design graphics as a formally recognized professional field.

2238 - Tues., 6/18, 8:30-10:15 am
Computer Graphics in Engineering Education I
Sponsor: EDGD
Co-Sponsor: Design in Engineering Education Division & the NSF
Moderator: Ron Barr, The University of Texas at Austin

Different issues concerning course development and teaching of computer graphics as a separate course or as part of a course on engineering design graphics are presented and discussed. The studies were initiated at an NSF Summer Seminar and Workshop. This is the first of two related sessions.

2438 - Tues., 6/18,12:30-2:00 pm
Computer Graphics in Engineering Education II
Sponsor: EDGD
Co-Sponsor: Design in Engineering Education Division & The National Science Foundation
Moderator: Davor Juricic, The University of Texas at Austin
(See session 2238)

2738* - Tues., 6/18, 6:30-8:00 pm
EDGD Annual Awards Banquet - $28
Moderator: Jon K. Jensen, Marquette University
The program will include presentation of the Division Distinguished Service Award. Social hour with sponsored bar will precede the meal.

3238 - Wed., 6/19, 8:30-10:15 am
Historical Perspectives & Research on Graphics in Engineering
Sponsor: EDGD
Co-Sponsor: Engineering Technology Division
Moderator: Frank Croft, The Ohio State University
Speakers present information from studies on the history and scholarly development of engineering graphics as a body of knowledge within engineering. An understanding of the evolving and changing role of the engineering graphics professional educator, the impact of computer graphics technology, and future directions for this field are discussed.

3438* - Wed., 6/19, 12:30-2:00 pm
EDGD Annual Business Lunch. - $17
Moderator: Jon K. Jensen, Marquette University
Open business meeting for all members of the Division.

3548 - Wed., 6/19, 2:30-4:15 pm
CAD Standards in Engineering Technology
Sponsor: Engineering Technology
Co-Sponsor: EDGD
Moderator: Craig Miller, Purdue University
The development of standards which reflect current industrial practice and are implemented through CAD technology and instruction are key issues. Both existing and proposed standards and practices are discussed.

* Denotes meal event.

Session locations are not available at the time of publication. ASEE will publish this information in the conference program.

The program looks exciting, the quality of papers offered appears to be very high, and the city is a jewel. We both hope to see you in New Orleans!

International Computer Graphics Calendar

by
Vera Anand

Feb 25 - 28, 1991
EDAC 91, European Design Automation Conf., Amsterdam, Holland. Contact: Secretariat, EDAC 91, CEP Consultants, 26-28 Albany St., Edinburgh EH1 3QH,

Scotland. Ph. 44 (31) 557-2478, Fax 44 (31) 557-5749.

Apr 1 - 5, 1991
24th Computer Simulation Conf., New Orleans, LA. Contact: George W. Zobrist, Computer Science Dept., Univ. of Missouri at Rolla, Rolla, MO. Ph. (314) 341-4836.

Apr 4 - 6, 1991
Computer Graphics and Education '91, Barcelona, Spain. Contact: Steve Cunningham, Computer Science Dept., Cal State Univ Stanislaus, Turlock, CA 95380

Apr 7 - 12, 1991
1991 IEEE Int'l Conf. on Robotics and Automation, Sacremento, CA. Contact: T. J. Tarn, Systems Science and Math., Campus Box 1040, Washington Univ., St Louis, MO 63130

Apr 22 - 25, 1991
NCGA 91, 1991 Nat'l Computer Graphics Assoc. Conf., New Orleans, LA. Contact: Keith Butler, Boeing, Advanced Tech. Ctr., PO Box 24346 M/S 7L-64, Seattle, WA 98124. Ph. (206) 865-3389.

Apr 28 - May 2, 1991
CHI 91, Conf. on Human Factors in Computing Systems, New Orleans, LA. Contact: Peter Poison, Psychology Dept., Univ. of Colorado, Muenzinger Hall, Campus Box 345, Boulder, CO 80309-0345. Ph. (303) 492-5622.

May 13 - 16, 1991
ICSE 13, 13th Int'l Conf. on Software Engineering, Austin, TX. Contact: David Barstow, Schlumbarger Lab for Computer Science, PO Box 200015, Austin, TX 78720-0015

May 15 - 17, 1991
CCW 91, Third IEEE Conf. on Computer Workstations, Cape Cod, MA. Contact: Keith Marzullo, Computer Science Dept., Upson Hall, Cornell University, Ithaca, NY 14853.

Jun 22 - 28, 1991
Computer Graphics Int'l '91, Cambridge, MA. Contact: N. M. Patrikalakis, MIT Rm. 5-428, 77 Massachusetts Ave., Cambridge, MA 02139. Ph. (617) 253-4555; FAX (617) 253-8125.

Jun 22 - 28, 1991
Computer Graphics International '91, Cambridge, MA. Contact: N. M. Patrikalakis, MIT Rm. 5-428, 77 Massachusetts Ave., Cambridge, MA 02139. Ph. (617) 253-4555; FAX (617) 253-8125.

Jul 29 - Aug 2, 1991
SIGGRAPH 1991, Las Vegas, NV. Contact: Michael Bailey. Ph. (619) 534-5142.

Aug 7 - 10, 1991
12th Annual Conf. of the European Assoc. for Computer Graphics, Vienna, Austria. Contact: Interconvention, Austria Center Vienna, 1450 Vienna Austria. Ph. +43/222/23 69/2643; FAX +43/222/23 69/648.

Aug 13 - 16, 1991
7th Scandinavian Conf. on Image Analysis, Aalborg Univ., Denmark. Contact: Prof. Erik Granum, 7th SCIA Conf. Chair, Lab. of Image Analysis, Institute of Electronic Systems, Aalborg Univ., Bade-

husvej 23, DK-9000, Aalborg, Denmark.

Aug 27 - 30, 1991
CADDM'91, Third Int'l. Conf. on Computer Aided Drafting, Design and Manufacturing Tech., Beijing, China. Contact: Prof. Chen Jiannan, P. O. Box 85, Beijing, China. Telex 22036 BIAAT CN.

Sep 2 - 6, 1991
Eurographics '91, Hofburg, Vienna, Austria.

For further information, contact Vera Anand, 302 Lowry Hall, Clemson Univ., Clemson, SC 29631. (803) 656-5755

The End of an Era

by
Pat McCuistion

The Creative Engineering Design Competition and Display has been held at the Annual ASEE Conferences since 1967. In that span of time engineering education has changed substantially. There has been a marked deemphasis of engineering graphics and lower-level design classes and an emergence of more theoretical courses. The design competition, as it has recently been presented, may not fit into the current mode of thinking.

An ad hoc committee was established at the ASEE Annual Conference in Toronto to study the current state of the EDGD design competition. At the EDGD Mid-year Conference in Tempe, the committee decided to suspend the design competition for the ASEE Annual Conference to be held in New Orleans. This decision was made so that we, as a Division, can have an opportunity to redirect the focus of the competition.

The design competition has had a positive effect on engineering education by giving enterprising students a chance to excel. It has also kept the EDG Division in the forefront of ASEE. We want to keep this positive effect alive. You can help the cause by voicing your opinion. Do you wish to keep the competition the same as it has been? If not, how would you change it? Please send your suggestions to:

Patrick J. McCuistion
120 Stocker Ctr.
Ohio University
Athens, OH 45701-2979

Call for Papers

EDGD Mid-year Conference
November 3 - 5, 1991
Old Dominion University
Norfolk, Virginia

A Potpourri of Engineering Design Graphics Ideas

Topics are limited to various aspects of engineering design graphics. If the response to the Call for Papers is suitable, a "poster session" may be initiated.

Abstracts of 250 words are due not later than July 1, 1991. Submit to:

J. B. Crittenden
Program Chairman, EDGD Mid-year Conference
EF, VPI&SU
Blacksburg, VA 24061-0218

Ph. (703) 231-6555

FAX (703) 231-7248

Notice of acceptance will be mailed by July 31, 1991. Completed papers will be due not later than September 15, 1991.

Editor's Comments

by
Barry Crittenden

My thanks to Nadim Aziz and the Geometric Modeling Committee for sponsoring this issue of the *EDG Journal*. Such work by Division members allows an issue of the *Journal* to be devoted to a single topic. I think you will find the four papers devoted to geometric modeling to be exceptional in content and timeliness.

At the June, 1990 ASEE Annual Conference, the EDGD Executive Committee accepted a proposal to initiate page charges for contributed papers published in the *Journal*. This proposal, recommended by the *EDG Journal* staff, went into effect for all papers received after June 27, 1990. It is intended solely to help offset the increasing costs of publication and mailing of the *Journal*. These charges are listed on the last page of this issue. Upon adoption of the page charge policy, a most generous offer was made by Sam Bridwell. He has agreed to assist financially any EDGD member unable to meet the page charge requirement. I assume this offer is subject to review by Sam at the end of the academic year. Thank you, Sam, for your continued interest in the Division and the *Journal*.

Work proceeds on the Division history by William Rogers. As requested on page 58 of the Winter, 1990 issue, your assistance is needed. Persons possessing any previous histories, historical notes, or other material, both archival and anecdotal, are requested to send this material to:

William B. Rogers
308 Sutton Place NE
Blacksburg, VA 24060-2630

All material will be returned to the sender after completion of the compilation. Significant contributions will be acknowledged and attributed in the *Journal*. Financial support for this special issue of the *EDG Journal* is being sought from the ASEE through its Centennial Activity Fund permitting grants not to exceed $1000 for acceptable proposals.

ENGINEERING DESIGN GRAPHICS JOURNAL

ISSN 0046-2012

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Scope

This journal is devoted to the advancement of engineering design graphics, computer graphics, and subjects related to engineering design graphics in an effort to (1) encourage research, development, and refinement of theory and applications of engineering design graphics for understanding and practice, (2) encourage teachers of engineering design graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses, and (3) stimulate the preparation of articles and papers on topics of interest to the membership. Acceptance of submitted papers will depend upon the results of a review process and upon the judgement of the editors as to the importance of the papers to the membership. Papers must be written in a style appropriate for archival purposes.

Submission of Papers and Articles

Submit complete papers, including an abstract of no more than 200 words, as well as figures, tables, etc. in quadruplicate (original plus three copies) with a covering letter to J. B. Crittenden, Editor, Engineering Design Graphics Journal, EF - VPI&SU, Blacksburg, VA 24061-0218. All copy must be in English, typed double-spaced on one side of each page. Use standard 8 1/2 x 11 inch paper only, with pages numbered consecutively. Clearly identify all figures, graphs, tables, etc. All figures, graphs, tables, etc. must be accompanied by a caption. Illustrations will not be redrawn. Therefore, ensure that all line work is black and sharply drawn and that all text is large enough to be legible if reduced to single or double column size. High quality photocopies of sharply drawn illustrations are acceptable. The editorial staff may edit manuscripts for publication after return from the Board of Review. Galley proofs may not be returned for author approval. Authors are therefore encouraged to seek editorial comments from their colleagues before submission of papers.

Publication

The Engineering Design Graphics Journal is published one volume per year, three numbers per volume, in winter, spring, and autumn by the Engineering Design Graphics Division of the American Society of Engineering Education. The views and opinions expressed by individual authors do not necessarily reflect the editorial policy of the Engineering Design Graphics Division. ASEE is not responsible for statements made or opinions expressed in this publication.

Subscription Rates and Page Charges

Yearly subscription rates are as follows:

ASEE member	$ 6.00
Non-member	$ 7.50
Canada, Mexico	$12.50
Foreign	$25.00

Single copy rates are as follows

U.S. member	$ 3.00
U.S. non-member	$ 3.00
Canada, Mexico	$ 5.00
Foreign	$10.00

Non-member fees are payable to the Engineering Design Graphics Journal at: The Engineering Design Graphics Journal, The Ohio State University, 2070 Neil Avenue, Columbus, OH 43210. Back issues are available at single copy rates (prepaid) from the Circulation manager and are limited, in general, to numbers published within the past six years. The subscription expiration date (the date of the last paid issue) appears in the upper right corner of the mailing label (for example, W91, for Winter, 1991). Claims for missing issues must be submitted within a six-month period following the month of publication: January for the Winter issue, April for the Spring issue, and November for the Autumn issue.

For technical papers received for review after June 27, 1990, a page charge for publication of accepted papers will apply. The rates are as follows:
$5/page for EDGD members
$10/page for non-EDGD members who are members of ASEE
$25/page for non-ASEE members
This charge is necessitated solely to help offset the increasing costs of publication. Page charges are due upon notification by the Editor and are payable to the Engineering Design Graphics Division at: J. B. Crittenden, Editor, EDG Journal, EF-VPI&SU, Blacksburg, VA 24061-0218.

Deadlines

The following deadlines apply for submission of articles, announcements, and advertising: Autumn issue - August 15, Winter issue - November 15, Spring issue - February 15.

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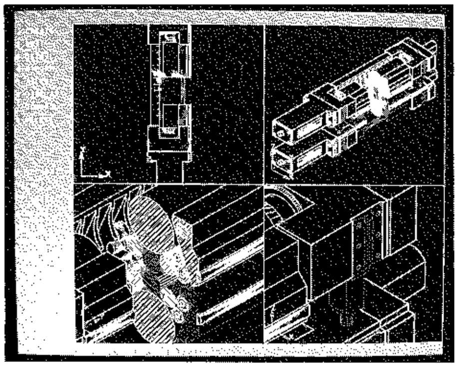

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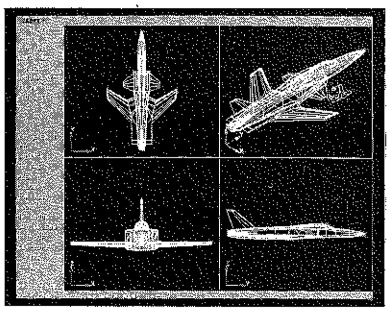

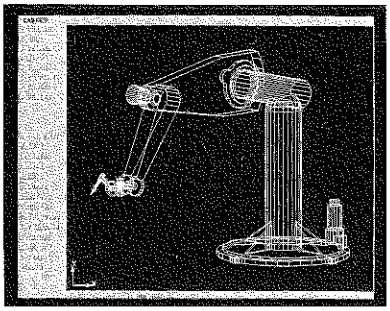

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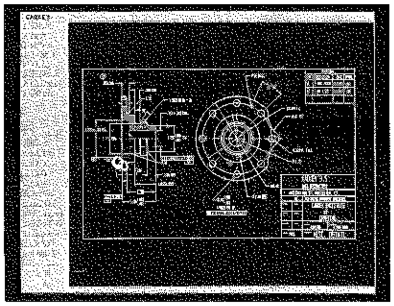

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