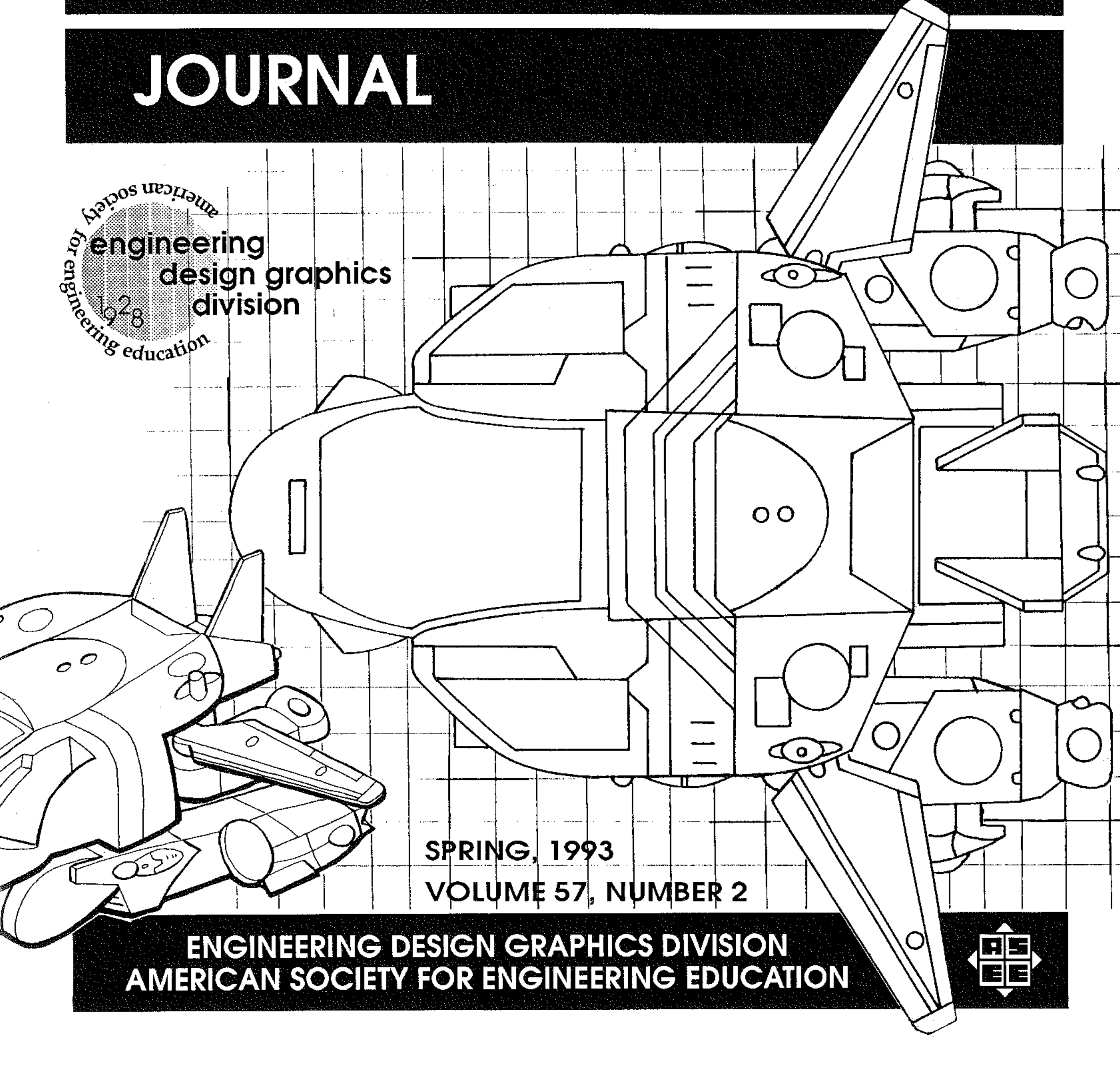
THE ENGINEERING DESIGN GRAPHICS JOURNAL



SPRING, 1993
VOLUME 57, NUMBER 2

ENGINEERING DESIGN GRAPHICS DIVISION
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

SilverScreen®

3D CAD/Solid Modeling Software

Announcement of Classroom Adoption of SilverScreen By the University of Virginia

Beginning in the Fall semester, 1993 the University of Virginia will adopt SilverScreen for use by its students in Engineering Concepts (ENGR 160). The course is taken by all freshman engineering students (approximately 425 students per semester).

Approximately 25% of this course will be devoted to CAD modeling using SilverScreen. ENGR 160 is linked to Engineering Design (ENGR 164). In ENGR 164 students will use SilverScreen for design projects. For the SilverScreen portion of the course students will use **Computer Aided Design Using Solid Modeling.**

Computer Aided Design Using Solid Modeling was written by Dhushy Sathianthan and is published by Schroff Development Corporation. This book is also used by Pennsylvania State University (University Park) in its freshman level course Engineering Methods and Graphics Communications (EG 50).

The adoption of SilverScreen by these universities represents part of the movement to teach solid modeling at the freshman level. SilverScreen is proving to be extremely effective in this setting.

Computer Aided Design Using Solid Modeling is available from Schroff Development Corporation for $16.50 per copy. To receive an examination copy contact Stephen Schroff.

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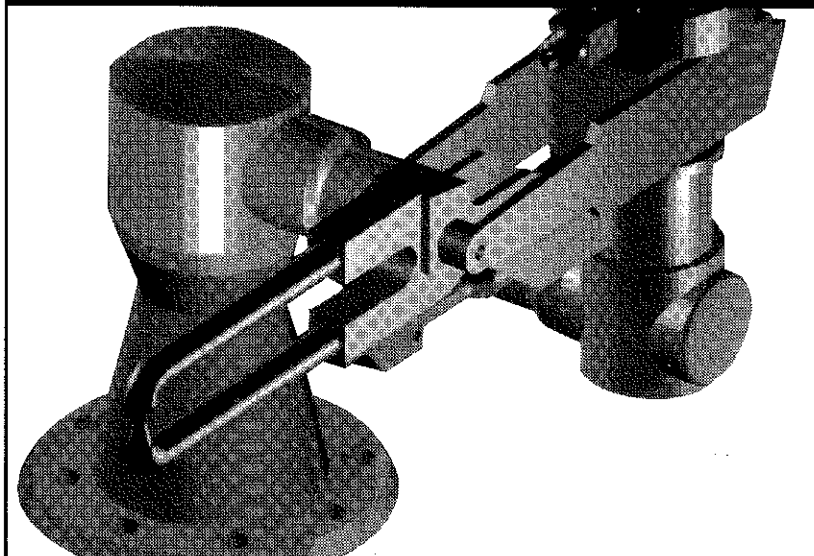

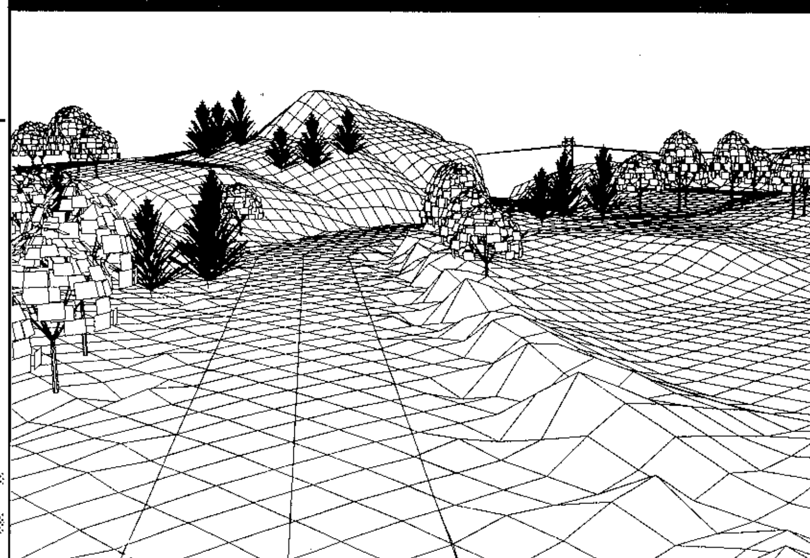

engineering design graphics division

THE ENGINEERING DESIGN GRAPHICS JOURNAL

Volumn 57 Number 3 Spring 1993

The *Engineering Design Graphics Journal* is the official publication of the Engineering Design Graphics Division of ASEE. The scope of the 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.

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. . . from the EDGE • Engineering • Design • Graphics • Editor

Although this is officially the Spring issue, the timing and some of the contents may vary slightly from most Spring issues. The ASEE Annual meeting has come and gone, and you will find several references to the 100th anniversary conference in this issue.

You will also find the winners of the Second Annual Irwin/CADKEY Drawing Contest. Shamefully, we had only 36 entries this past year. I encourage all of you to get with your students and send in those entries. Surely we can have more than 36 entries in the Third Annual Contest. If you did not receive information about the contest, (or misplaced the information you received), see page 46 of the issue. This can be a great honor for the students who win in each category.

Under the guidance of Patrick McCuistion, there will be a National Design Graphics Competition for Freshman students, which will be held in conjunction with the 1994 ASEE Confernce at Edmonton, Canada. See pages 41-45 of this issue for more information. Pat has worked long and hard on this and we hope it will be a great success and will continue for years to come.

I would like to congratulate Mary Jasper on being the recipient of the EDGD Distinquished Service Award. Mary was awarded this honor at the EDGD Banquet at the ASEE Annual Meeting.

Mary A. Sadowski
Editor

Mary Sadowski, editor of the *EDG Journal*, displaying the Special Edition of the *Journal*, a history of EDGD written by Bill Rogers.

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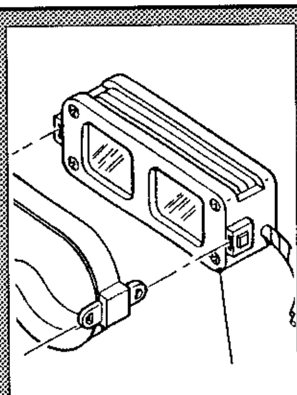
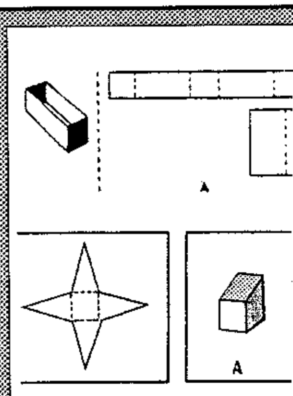
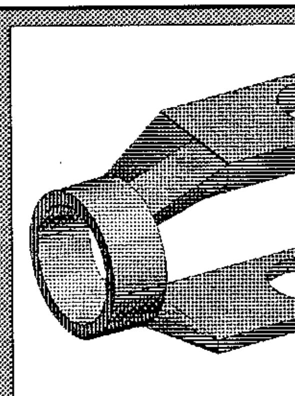
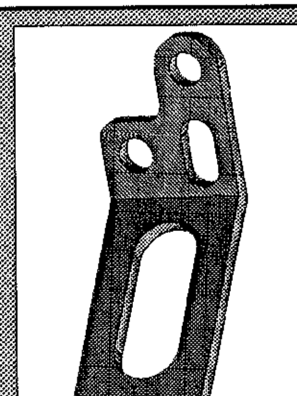
• *Cover illustration by* ***Dane Carter***









Virtual Reality: Implications for Research in Engineering Design Graphics

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Abstract

Computer systems have recently been developed which enable the prototyping of 3D CAD models as though the designed objects were actually real. With this emerging technology, currently referred to as Virtual Reality, the systems incorporate the use of display devices which are worn on the user's head, instrumented gloves which provide tactile feedback and enable the intuitive manipulation of virtual objects, and 3D acoustic displays. For its first major objective, this paper gives a brief overview of such systems, reviews a number of current applications developed for use within the engineering and design community, and suggests future applications. The techniques described can be applied to a wide variety of other design evaluation, and educational research needs.

All scholarly disciplines and recognized professional fields are founded on applied research. In engineering design graphics, efforts at applied research in the area of spatial acuity have been ambiguous, inconclusive, and otherwise hampered because of the complexity of the task and the available tools. Prior to the advent of computer graphics and its associated dynamic 3D capabilities, research in 3D spatial acuity has been reliant on static or primitive measuring instruments. These tools have proved insufficient to monitor and measure the spatial acuity and visualization skills process. The second major objective of this paper is to suggest that Virtual Reality offers the necessary capability, because of its immersive nature, to monitor, record, and allow for analysis of the types of spatial acuity and visualization skills useful in engineering design graphics. Specific scenarios for developing engineering design graphics research tools utilizing VR technology are discussed.

Introduction

While computing technologies continue to increase in capability, the entire issue of how a user interacts with these systems for the most part remains unchanged. Certainly the quality and functionality of monitors, mice, digitizers, and keyboards have taken us far, but there are some fundamental constraints within their design which continue to be quite limiting.

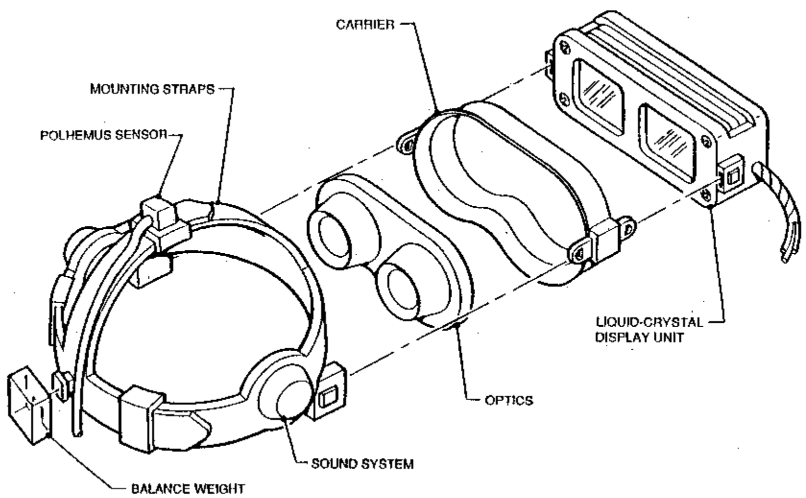

Figure 1. Components of a head-mounted display

These difficulties begin with the fact that our natural psychomotor and perceptive abilities are optimized to process information in three dimensions. Consider the way in which we evaluate and interact with our normal everyday surroundings. We walk through, look up, down, sideways, reach out and manually handle objects, and listen. Simply stated, we are spatial information processors.

Yet, computing machinery has, for the most part, been designed to supply and receive information in only two dimensions. The overall effect is that a bottleneck exists between the computer and the human operator. In the case of the design community, users have to interpret their thoughts as a series of typed commands or movements in three separate axes expressed in the following manner: "To rotate about the X-axis, turn this dial, for Y, this dial, and so on."

Virtual reality (VR), the latest development in the fields of user interface design and interactive computer graphics, offers significant advantages over the classical methods of design manipulation and evaluation. Unlike standard computer workstations which simulate 3D images on a 2D display, virtual interface systems, in effect, alter the current interface and immerse the user 'within' the model or information space, allowing the user to freely explore the design from a first person perspective.

The principle difference between VR and a normal workstation is the use of a stereoscopic head-mounted display as shown in Figure 1. Miniature liquid crystal displays (LCD's), one in front of each eye, provide the stereo images. Mounted on top of the display is a sensor which tracks the position and orientation of the user's head. The information from the sensor is used to stabilize the images displayed in the head-mount as the user moves about.

Applications of VR

The number of specific case studies involving the use of virtual interface technology within the design community is growing rapidly. The results of these studies demonstrate that VR is indeed a highly useful tool for evaluation of designs, minimizing last minute surprises and potentially increasing creativity.

Architectural Walkthrough

One of the most frequent applications of this technology to date has been in the exploration of architectural models. A number of excellent examples can be found at the University of North Carolina. In the last three years, VR has been used to evaluate designs for a number of new structures on the campus, including a church and the building which now houses the Department of Computer Science. Both of these structures were actually walked through prior to a single spade of dirt ever being turned in the construction process.

In both examples, models of the structure were initially defined using AutoCAD and other in-house design packages and loaded into a high-end computer graphics workstation for rendering images. Instead of relying only on standard 2D monitors and blueprints to evaluate the models, engineers utilized stereoscopic head-mounted displays.

Variation of one's viewpoint was accomplished through the use of a treadmill with handlebars. To move, the user simply walks as though touring the structure after it has actually been built. To turn corners and explore connecting rooms and hallways, the user merely turns the handlebars in the desired direction of travel. One's rate of movement through the model is controlled by the user's length of stride and speed at which the steps are taken, just like the real world. While moving through the model in this fashion, the user is able to freely move his or her head from side to side and up and down. You can even turn all the way around and walk backwards, seeing objects and features within the model grow smaller as you pass and move further away.

During the process of touring the models in this fashion, a number of design flaws were uncovered which were completely missed during the evaluation of the designs on a standard workstation monitor and paper. As one would expect, implementing changes to the position of a wall staircase or window in a CAD model is a trivial task when compared to making the same changes in concrete once construction has actually begun.

Acoustic Evaluation

Adding to the architectural walkthrough described above, there exist numerous instances where one would like to investigate the acoustical properties of a design prior to the model actually being constructed, particularly in architectural engineering circles. Due to the computational complexity of such tasks, real-time simulations have been limited to free-field rooms (no echoes).

Recently, research conducted at NASA Ames Research Center and Crystal River Engineering has resulted in the development of systems which also support the simulation of such factors as reflecting surfaces (walls) and high frequency waveform absorption by a wide variety of surfaces. These 3D acoustic displays are delivered over studio quality headphones and can be correlated and stabilized with the visual models.

Aircraft Design

The Advanced Technology Center at Boeing Aircraft in Seattle can be credited with the first industrial application of virtual reality. This group utilizes VR to experimentally prototype CATIA models of new aircraft, including a tilt rotor transport known as the VSX. Potential users of such a system would be an engineer or pilot who wants to study a particular aircraft design for operability, maintainability and manufacturability while it exists in digital form.

Following the preparation of the initial CAD designs, models are loaded into twin graphics workstations (one for each eye's view). Images are presented to the user through a stereoscopic head-mounted display as shown in Figure 2. Again, unlike viewing on a 2D monitor, users of the systems are able to experience the model as though a full scale mockup were parked within the design lab. So, if the user enters the simulation within the crewstation facing the control panel, one need only physically turn around to see down the aisle into the passenger compartment.

Figure 2. Cyberface™ VR head-mounted display

The user also has selection of means through which to move within the model. Since the position of the user's head is monitored, the first is to simply walk in the desired direction of travel. As there is no treadmill in use here, movement is limited to 3-4 feet because of cables connecting the display to the graphics hardware. Another option is to utilize a glove-like input-output (I/O) device known as the DataGlove shown in Figure 3. While seated or standing, you simply slip on the glove and point in the desired direction of travel. The gesture recognition capabilities are made possible by flex sensors affixed to the outside of the fingers and a position sensor attached to the back of the hand. Point with one finger to go forward, two to travel backwards, thumbs up to enlarge the scale of the model, etc.

This system also allows the user to directly interact with various objects within

Figure 3. Headset and VPL DataGlove™

the model. Again using the DataGlove, the user simply reaches out and grabs an object just as you would if the object were real. A small 3D icon in the shape of a hand is provided within the model for the necessary hand/eye coordination. So you can reach out and manipulate controls, open and close hatches and reposition seats, windows and overhead storage bins.

Other potential application areas under consideration by this group include crewstation ergonomic studies. Why wait for a mockup to be built, only then to discover that the controls need to be positioned differently or that more of the wings need to be visible? With VR, such discoveries can be made well prior to the design ever leaving the engineers work area.

Automotive Design

Similar applications can be found within the automotive design community. By allowing engineers to experientially prototype autobody and interior designs prior to commissioning the creation of scale clay models, design strengths and weaknesses can be identified much earlier in the development process. VR can also facilitate other processes such as rear vision studies and assembly line processes.

VR and the Investment Community

Maxus Systems International of New York is credited with the development of the first commercial use of virtual reality in the field of high finance and money management. Developed for TIAA-CREF, the $106 billion college teachers' pension fund, the system allows fund managers to track Pacific Rim markets in an easy, highly intuitive manner.

The system, known as Capri, displays financial information in such a way that it is very simple to understand and follow. The Capri virtual world consists of a grid which looks much like a giant checkerboard. One side of the grid is labeled with a series of industry groups, such as financials, utilities, automotive, pulp, and so on. An adjoining side is labeled with the names of various stock exchanges such as Singapore, Thailand, Tokyo, and Hong Kong. Located within each square is a series of chips, each of which represents a particular security. The position of the chips within each square on the grid clearly indicates the market and industry that the stock falls into.

Each of the chips also has characteristics which aid the fund manager in understanding more about it. For example, the color indicates price performance; red denotes that the stock is down from the previous day, blue represents a rise, and so on. A spinning chip indicates that the security has features that are considered more appealing than others in that industry. A blinking chip indicates that the security has the potential to be bought and sold in several markets simultaneously. The chip's position above or below the grid indicates the stocks measure of activity against others in the same industry.

Remember that all of the information displayed in the Capri system is the same that the fund manager would receive through a normal data feed, only it is displayed in a manner which takes greater advantage of our natural psychomotor and perceptive abilities. One need only alter a viewpoint to learn more about the various securities as needed.

Bringing VR into the Design Shop or Classroom

Integrating VR into an established CAD environment is a trivial task when compared to that which was required only two years ago. Also, VR does not carry the normal headaches associated with implementing new technologies or products in the workplace. No need to buy everyone new workstations, change design packages, lay a custom network, etc. In relation to CAD, VR can be principally thought of as a powerful visualization tool with which to explore and analyze designs created in CAD. It is not meant to replace any current methods, but to supplement.

Most commercial systems consist of a host computer, head-mounted or head-coupled display and a few peripherals. All of the components can be mounted in a rack enclosure and take up surprisingly little space. When a design has been completed at your regular workstation, transfer the object geometry over to the VR station, put on the display and evaluate your work as if it were already constructed.

Most popular design formats are supported by each of the various commercial systems which are available. These include models which are created using AutoCAD, CATIA, MultiGen, Wavefront Advanced Visualizer, and Alias.

Prices for complete systems range anywhere from $12,000 upwards to a quarter million. Depending on the hardware currently in possession, individual components can be acquired and a system pieced together to meet specific needs. Microcomputer based systems are already available from World-Tool Development Systems, based on the Intel 33MHz 80486 desktop computer (Aukstakalnis) and from VPL using a Macintosh Quadra 900 as a host computer.

Virtual Reality and Engineering Design Graphics

The potential applications of VR to engineering design graphics are 'virtually' unlimited. Virtual reality is already playing a valuable role in support of the engineering design process. It can also be adapted to develop CAD educational and training materials which can place students directly in touch with the objects they are attempting to model or 'draw.' For the student using a VR based CAD system, problem solving using plane and solid geometry may be experienced first person by allowing the student to be directly immersed in and in control of changing the geometry. Future advances in VR technology will also allow two or more users, such as student and instructor, to simultaneously share and interact with the same VR environment.

Historical Research Methods in 3d Spatial Acuity and Geometric Visualization

Numerous statistically validated tests have been developed for measuring or detecting tendencies in spatial acuity and the visualization of 3D objects. Eliot and Smith cite nearly 400 tests developed and used over the last 70 years to measure various attributes of spatial ability. Within this domain, tests relating to engineering design graphics tasks include mental rotation of solids, pattern recognition, view orientation, perspective, and assembly. Figures 4-6 illustrate test items from several validated tests which have been used as measures of spatial acuity.

Research efforts in engineering design graphics have typically focused on interpretation of orthographic multiviews, spatial acuity, and the visualization of points, lines, planes, and solids. Historically, tools and techniques used for educational research have consisted of static paper tests, mutilated blocks of a great variety, transparent boxes, mirrors, and more recently, multimedia and computer graphics. Due to the complexity of recording and measuring spatial acuity tasks, more sophisticated tools and methods for measuring spatial acuity attributes should be deemed highly useful. How does applied research in measuring geometric comprehension and spatial acuity progress to the next level?

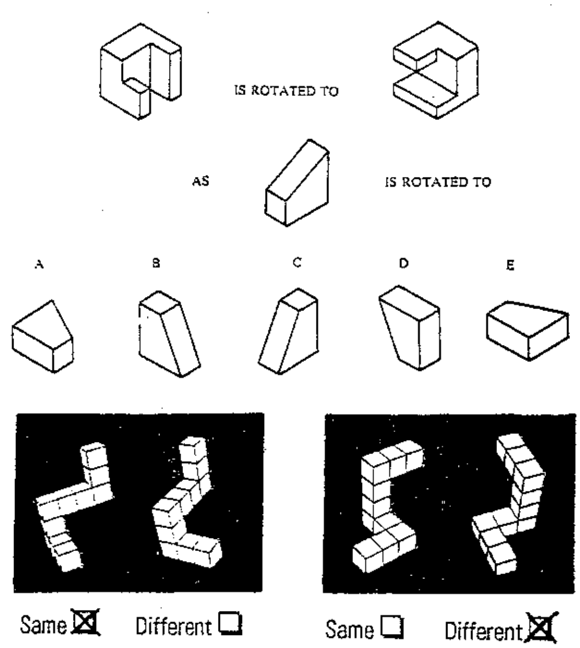

Figure 4. Mental rotations test items.

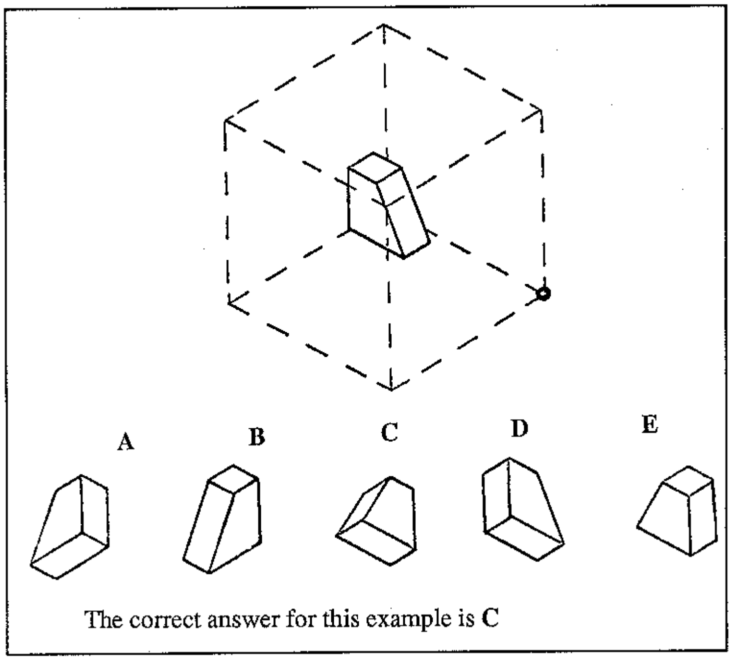

Figure 5. Object/viewer orientation test items.

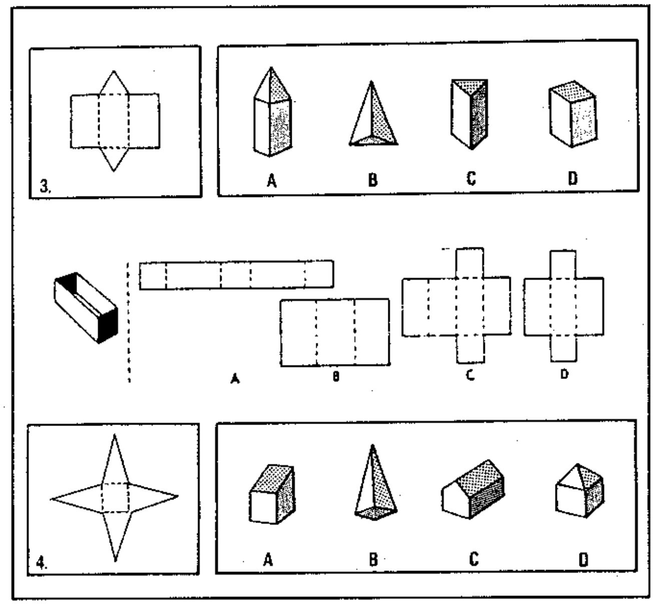

Figure 6. Pattern development test items.

What is required are testing methods which track, record, and analyze how and when subjects arrive at the correct interpretation of what is visually and geometrically correct. Testing methods which measure a more complete range of variables will require supporting technologies which, up to this point, have been difficult for researchers in engineering design graphics to acquire or develop. Because of its immersive and potentially highly interactive-real time nature, Virtual Reality shows great promise for expanding measurement and data gathering capabilities for researchers.

Research Strategies with VR

Studies which have combined real and computer-generated models in engineering design graphics indicate that many students are aided in advancing their spatial abilities (Miller). The immersive and highly interactive nature of modeling in Virtual Reality should have a similar positive effect on students. As a research tool, the addition of a transparent but real-time data acquisition system to this process is the key for allowing researchers to measure and record desired variables. The resulting database is then available for immediate statistical analysis.

Although both static and dynamic testing modes are believed to be of value as testing methods, very little has been done in the area of comparing static and dynamic testing methods. This is in large part due to the complexity and expense of creating effective dynamic animated testing methods.

What types of tests might be envisioned for VR? Tests which require the subject to manipulate, match, and make decisions about the geometric nature of 3D models are a logical area in which to develop tests. Tests which measure the rate of speed for recognizing pattern development and object orientation for design or assembly purposes should also prove valuable. A number of possible scenarios for dynamic VR visualization testing are described below:

Scenario 1
ROTATION

The subject is confronted with a row of 3D models which are rotated into different positions. Some, but not all of the models, are identical. The subject is required to reach out, grab, and rotate the models until the matching models can be identified. A custom developed virtual reality program keeps track of correct matches, the amount of time required to solve each problem, the method in which the choices were rotated, and other variables of interest. Testing complexity or level is varied by limiting the degrees of freedom of rotation allowed for the models.

Scenario 2
PATTERN DEVELOPMENT

The subject is confronted with a flat pattern of a 3D object and a series of 3D models pictorially arrayed around the pattern. Although all of the models appear similar to the pattern, only one of the models can be developed from the pattern. The subject is required to reach out, grab, fold and unfold the pattern until its matching model can be identified. The program keeps track of correct matches, the amount of time required to solve each problem, the steps in which the pattern is folded, and other variables of interest. Testing level is varied by the complexity of the pattern.

Scenario 3
MULTIVEW RECOGNITION

The subject is confronted with the orthographic multiview representation of an object on a plane and a series of 3D models of the same object arrayed or floating around the multiview in differing or random pictorial rotations. The subject is required to reach out, grab, and rotate the models until the orientation of each model is correctly revolved and aligned to match the orthographic multiviews displayed on the plane. The program keeps track of the amount of time required to align each model with its associated multiview representation. Additionally, the program monitors the method in which the models are rotated, amount of time required, and other variables of interest. Testing level is varied by the complexity of the object.

Scenario 4
BOOLEAN MANUFACTURER

The subject is presented with a 3D solid model of a finished manufactured part surrounded by a series of 3D primitive solid objects of various shapes. The primitive shapes are related both to the finished part and the associated manufacturing process required to make the part. The subject is required to duplicate the finished part by performing necessary boolean operations with the given primitive shapes. The objective of the test is to measure or explore the relationship of modeling and design faced with the reality of actual constraints of materials and processes. Testing level is varied by the complexity of the part and the processes used in its creation.

Scenario 5
DESCRIPTIVE GEOMETRY

The subject is confronted with a series of spatial problems or tasks such as solving for the shortest connector between two pipes; a task which requires an understanding of how to measure or extract the true lengths and point views of a line. The pipes are fixed in space and are visually presented to the subject such that both are oblique to the line of sight. Both pipes are shown as translucent with brightly colored center lines. Although the pipes are fixed, the observer may freely move around and 'through' the pipes. When the observer moves to a position such that the line of sight is 'approximately' parallel to a pipe center line, the shortest connector appears on the display. The program keeps track of the observer's orientation, position, and the amount of time required to acquire the correct solution. Testing level can be varied by the realism of the display, the use of reference planes as visual cues, and the amount of time allowed for each task.

Scenario 6
ASSEMBLY and DISASSEMBLY

The subject is presented a series of individual 3D models of parts in an assembly. With collision detection and interference checking in effect, the parts are to be assembled. Assembly motions can be either tactile or robotic in nature depending on the objective of the task, ie., direct output to automated assembly. Also depending on the test objective, the subject may be presented with an orthographic multiview assembly drawing against which to compare the efforts of the subjects. The program keeps track of the amount of time required to complete and the method in which the assembly is completed. Additionally, the program monitors efficiency of motion, or steps in which the models are rotated, amount of time required, and other variables of interest. Testing level is varied by the complexity of the assembly.

Scenario 7
CONVERGENT vs. PARALLEL

Is convergent (perspective) display an inherently superior method of displaying a model for visualization purposes? This comparative testing method is similar to rotation testing. In test one, the subject is confronted with a row of 3D models which are displayed using parallel projection and rotated into different positions. Some, but not all, of the models are identical. The subject is required to reach out, grab, and rotate the models until the matching models can be identified. In test two, subjects are asked to perform the same types of tasks, but all models are displayed in perspective mode. The programs keep track of correct matches, the amount of time required to solve each problem, the method in which the choices were rotated, and other variables of interest. Testing complexity or level is varied by limiting the degrees of freedom of rotation allowed for the models. Additionally, the familiarity of the objects is a factor. Spatial perception of perspective is based on visual experiences related to the size or scale of the objects being viewed in the observer's visual environment. Objects which are perceived as 'large', such as buildings or bridges, may bias or influence the subject's judgement. Models displayed in parallel (axonometric) mode are usually of relatively 'small' mechanisms and parts which are relatively close to the observer. Therefore, measurements of the influence of 'object familiarity' and viewing distance on perception must also be considered.

The Role of Statistical Analysis

A key feature of all Virtual Reality testing scenarios that must be programmed into VR software for research purposes, is that subject responses need to be tracked in real-time by a transparent built-in data-acquisition program which compiles an underlying database for each variable at near real-time speed. This database can then be directly fed into a statistical analysis package for analysis, correlation, and comparison of the selected variables. By combining this method with varying levels of test complexity and subject background, a statistical profile may be constructed describing the motor skill and cognitive processes at work when spatial acuity tasks are being solved. This may mark the beginning of clarifying the elusive 'visualization' paradigm for effective applied research in engineering graphics.

Conclusions

The implications for developing and applying Virtual Reality based tools to applied research in engineering design graphics are exciting to speculate. As a professional discipline, the future of engineering design graphics is imbedded in and heavily dependent on emerging technologies. If EDG is to remain an established formal discipline and profession with its own recognized research methods, it is the responsibility of current professionals to explore, articulate, and apply these new technologies to the discipline. Virtual Reality offers much promise in this area of applied research.

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Construction Strategies in Solid Modeling

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Abstract

Methods for the construction of solid models are compared. A variety of parts are selected and modeled using constructive solid geometry and boundary representation methods. The models are evaluated based on the effort required to create the model and the size of the resultant model. Concepts used in solid modeling are identified and recommended for the development of curriculum or training programs in solid modeling.

Introduction

Graphics has long been recognized as the means for communicating geometric information between engineers, designers, manufacturers and technicians. Traditionally, the standard for graphical communication has been the orthographic drawing. With the introduction of computer graphics, computer aided design and drafting systems effectively replaced the drafting table, but orthographic line drawings based on wireframe models remained the standard. Recent advances in computer graphics and solid modeling, however, have changed the game. Solid models are complete, unambiguous representations of real physical objects and can be used effectively in many kinds of engineering analyses. As a result, it is imperative that the solid representation of the part be as accurate as possible. The model must be suitable not only for a graphical representation of the object, but also for engineering analyses such as mass properties, finite element analysis, manufacturing, and similar engineering applications which require knowledge of the geometric configuration of the part.

Two common methods of solid modeling are boundary representation (B-rep) and constructive solid geometry (CSG). Most commercial solid modeling packages are hybrid systems, allowing the designer to choose either modeling method, or sometimes a combination of the two. As a result, the solid model representation of the part is not unique. The choice of construction strategy or modeling method for a given part may depend upon many factors including the designer's knowledge of modeling methods, ease of construction with the particular software system, and intended use of the model.

Researchers in the area of graphics education have recognized the need for reform in teaching of engineering graphics (Barr and Juricic, 1990 & 1992; Bertoline and Pleck, 1990; Pleck et al. 1990; and McGrath and Bertoline, 1990). The need for updated graphics education in industry is particularly important since many working designers and engineers were taught conventional drafting practices and may not understand the concepts necessary to construct solid models. These new solid models will be used not only for communication and documentation purposes, but also for analysis and manufacturing. Furthermore, since the model is not unique, it is important for the designer to select appropriate modeling methods based on the anticipated uses of the model.

This paper identifies modeling strategies used in the construction of solid models and compares models created using various modeling strategies. The objectives of this study are to recommend suitable solid modeling strategies for various engineering applications and to recommend methodologies for teaching solid modeling to engineering students and practicing designers.

Overview of Solid Modeling

Wireframes and Surface Models

Conventional drafting practices and early CAD systems define objects using a wireframe representation. Basically, the object is defined by specifying the location of its edges (Wellman, 1966). For complex sculptured surfaces, the surface profiles or contours were specified, and a notation made to indicate that a "blend" between contours would be made. The actual shape of the part was only defined in the manufacturing stage. No rigorous mathematical description of the part geometry was specified by the designer, and therefore was not available for analysis. Furthermore, the actual shapes of manufactured parts would vary according to the skills of the pattern-maker or machinist who manufactured the parts.

Due to limitations of wireframe models, surfacing capabilities were added to CAD systems early in their development. Surface descriptions allow for hidden line removal and the definition of non-planar faces. The most common surfaces were analytical surfaces such as conics and blended surfaces such as ruled surfaces and b-spline surfaces, which rely upon the definition of the surface boundaries or edges, or may be a blend of interpolation points or a mesh of points across the surface (Rogers and Adams, 1990; Mortenson, 1985; Zeid, 1991). Surface models may be used for some engineering applications such as mass properties or numerical control (NC) machining.

Constructive Solid Geometry

Constructive Solid Geometry (CSG) modelers utilize simple geometric building blocks, such as cubes, cones, cylinders, tori and spheres, to construct objects. These building blocks are known as primitives. The modeler assembles primitives into a design object through a series of Boolean operations (union, intersection, subtraction) and unary operations (copying, mirroring, scaling, rotation and translation). The design object is represented by a binary tree, with each branch holding a set of primitives, and each node containing a Boolean or set operation. If necessary, the leaves of the tree each contain a single primitive with a unary operation (Mortenson, 1985; Zeid, 1991). For example, a pencil would be represented by a tree having two leaves (a cylinder and a cone) with a union operation at the connecting node.

Boundary Representation

Boundary representation (B-rep) modelers define 3-dimensional solid volumes or objects by identifying the 1- and 2-dimensional entities which bound the volume. B-rep modelers represent a solid as a hierarchical series of segments, faces or half-spaces, each bounded by its edge and terminated by its vertices. A solid boundary is generated by the union of all the faces forming the solid. In addition, the system must identify the "inside" and "outside" of each face (Mortenson, 1985; Zeid, 1991).

Boundary representation techniques may be used to define simple parts composed of planar surfaces and conic sections; however, the great advantage of boundary representation methods is in their ability to accurately define complex contoured surfaces. Precise mathematical algorithms are used to specify functions for blending surface contours or meshes of data points to be interpolated over a surface area. Skinning refers to a technique whereby a series of surface contours is blended together. Sweeping refers to the generation of a solid as the region which is traversed by a closed cross-section or profile as it is moved along a specified path. Extrusions and revolute solids are special cases of generalized swept solids (Zeid, 1991).

Concepts In Solid Modeling

Several important concepts in solid modeling and CAD are identified. These include:

A. The ability to visualize complex objects and parts as collections or combinations of simple primitive solids. An understanding of Boolean or set operations is required for CSG. In particular, the concept of set intersection is particularly useful in solid modeling, but may be conceptually difficult for students and designers.

B. The interpolation or blending of points to form space curves such as splines, and the blending of curves or contours to create smooth surfaces. The selection of surface contours, sweeping paths and blending functions will determine the shape and degree of smoothness of the contoured solid surface. B-rep methods rely heavily on blending or interpolation to create contoured surfaces.

C. Unlike wireframe models, solid models are not unique representations of the object. Most commercially available solid modelers are hybrid systems which incorporate both CSG and B-rep methods due to the simplicity and compactness of the former and the flexibility in modeling complex objects afforded by the latter. Even a simple part such as a cylinder may be represented by a single primitive, a revolute solid, or an extruded circle. Depending upon the rendering methods used, these differences may not appear in the visual or graphical representation of the model on the computer screen, but the data structures will be quite different. Thus it may be difficult to compare and evaluate models created on these systems since the generation of the model is greatly influenced by the construction methods used by the designer (Barr and Juricic, 1991).

It is important that designers using solid modeling systems be familiar with different construction methods and multiple representations of parts, so that appropriate choices can be made during the modeling process.

Methodology

Several objects were selected to study different methods which could be used to create solid models using a commercial solid modeling system (11). The selected parts were modeled using different construction techniques and modeling strategies. Criteria were selected to evaluate and compare the various construction techniques. Some of the parts were also modeled by several individuals with various levels of experience in CAD and solid modeling using different solid modeling systems. The solid modeler used for this study uses both CSG and B-rep methods as well as some special functions for adding typical machining features such as fillets, chamfers, and countersunk or counterbored holes. A dual representation of the model is maintained; an unevaluated CSG tree and a planar-faceted approximation. The approximate model is used to calculate complex curve and surface intersections and can be quickly rendered by graphics hardware.

Classification of Parts

A solid model of an object or part can be classified in terms of the number and complexity of the entities used to create the model. The relation between the number and complexity of the entities in a part can be seen in Figure 1.

This figure plots the complexity versus the number of entities in a part. Parts may generally be grouped in one of four

<table>
<tr><td rowspan="2">Complexity of Entities</td><td>Category 2
High Complexity
Few Entities</td><td>Category 4
High Complexity
Many Entities</td></tr>
<tr><td>Category 1
Low Complexity
Few Entities</td><td>Category 3
Low Complexity
Many Entities</td></tr>
<tr><td></td><td colspan="2">Number of Entities</td></tr>
</table>

Figure 1. Part Classification

categories. For instance, a washer can be represented as the difference of two primitive cylinders (small number of simple entities), and would be grouped in Category 1. An airfoil also has very few entities, but the complexity of the entities involved (spline contours used to generate skinned solids) is very high. It would be grouped in Category 2.

Selection of Parts

Parts were selected for the study based on the following criteria:

1. The parts had to encompass the entire range of complexity. The parts selected contained entities which ranged from the simplest building blocks such as boxes, cylinders and cones to complex ones such as skinned surfaces.

2. The parts selected had to cover a broad range of model sizes. The number of entities ranged from two or three entities to twenty or more entities per part.

3. The parts selected had to make use of all the available construction techniques, such as Constructive Solid Geometry (CSG) and Boundary Representation and special features such as holes, fillets, chamfers, etc. It was very important to select the parts in a "balanced" manner so as not to over-value one particular construction technique. In addition, most of the parts selected had to have the flexibility to be created using different construction techniques.

4. Parts from Categories 2 and 4 (entities of high complexity) will be excluded from these studies since they do not qualify under criterion 3 above. These parts may, however, be included in the user surveys as described below.

Development of Construction Strategies

For each part, several models were generated using different construction strategies such as "pure" CSG, skinning and sweeping, extrusion or revolution, or combined methods. In order to identify methods which were suitable for each part, the designer must consider different strategies for the part construction. In the case of CSG methods, the designer decomposes the part into a collection of simple volume primitives such as spheres, cylinders and boxes. These primitives are then combined using the boolean union operation. Some features of the part such as holes may be modeled as "negative" volumes, created by boolean subtraction. More complex geometries may be created based on the boolean intersection of two solids. The models created using CSG methods are limited to the domain of parts which can be enclosed by surfaces which are contained within the collection of simple primitive surfaces available in the solid modeling package.

Boundary representation methods include sweeping and skinning techniques. These methods are based on the identification of profiles, edges, or contours which represent the boundaries of the part. Sweeping methods such as extrusion and revolution can be used for parts which have distinct planar profiles. These objects are often referred to as 2-1/2 D parts. The designer creates a 2D wireframe profile using lines, arcs and/or splines, then identifies an extrusion direction or axis of revolution to generate the solid. All of these solids can also be modeled using CSG methods if the primitive set includes the torus. Profiles may also be swept along any arbitrary path or 3D space curve to generate more complex solids with a uniform cross-section.

Skinning methods must be used to create sculptured surfaces, parts with tapered cross-sections, and other complex geometries. The designer must identify a series of cross-sections or profiles which are blended to form the surface of the desired solid. The shape and smoothness of the sculptured surface depends upon the selection of section curves, sweep or path curves, and the blending algorithm used.

In addition to the "pure" CSG and sweeping methods, several of the selected parts were modeled using hybrid techniques which combined extruded solids and simple primitives using boolean operations. In particular, many parts may be modeled using their orthographic projections as profile curves, then performing a boolean intersection of the extruded profiles. For each part in the study, at least two different construction strategies were evaluated.

Evaluation Criteria

Three criteria were used to evaluate the solid models generated in this study. The first one measures the amount of data entry or input required to construct the solid model of the part. The second criterion measures the data storage requirements for the solid model. The third measures the size of the model by the number of entities (primitives) and operations (nodes) in the CSG tree of the part.

The input required to build the model was measured based on the number of parameters specified by the designer. It is assumed that the designer will be as efficient as possible in selecting suitable coordinate systems and the order of entity construction. The basic building blocks were identified from a geometric standpoint. For instance, a line placed on the workplane was identified as a two-step process. Similarly, a cylinder placed with its axis parallel to one of the coordinate axes requires four inputs - the location of the cylinder origin, the choice of axis, the radius or diameter, and the height.

System utilities are functions that allow the user to modify the modeling environment. Utilities include rotation or translation of the local construction axes, changing workplanes, etc. Unary operations are the functions available on the system that allow the user to modify a model. Examples of these unary operations include mirror, move, rotate, copy, etc. Steps used in the construction of parts for system utilities and unary operations on parts were counted as input requirements.

Data storage requirements were measured by determining the number of bytes generated by each model. Since the chosen solid modeling system uses an integrated database for all parts, it was necessary to measure the size of the database immediately before and after the creation of each part. Overhead associated with file generation was avoided whenever possible.

The solid modeler also generates a CSG tree for each part. Models created using b-rep methods are not generally represented in this tree-like structure; however, a modified tree structure is proposed to encompass these models. Thus, a section curve or contour used to generate a skinned or swept solid would be represented as a union of its constituent lines, arcs and/or spline entities. B-rep operations such extrusion, revolution and skinning are then represented as nodes on the CSG tree. Features are represented as unary operations or nodes in the tree. In an effort to better represent the efficiency of models, the new trees were also no longer limited to binary nodes. At a given node, more than two branches could come together as long as the operation at the node included all the branches.

The node operations and their symbols are listed here:

Union (U)
Subtraction or Difference (D)
Intersection (I)
Skin or Sweep (S)
Extrusion (E)
Revolution (R)
Features (Hole, Fillet, Chamfer) (F)

To evaluate a construction technique using the CSG tree size, one would simply count the number of leaves and nodes in a tree.

These evaluation standards are by no means absolute, however, they serve as a basis for comparison of solid models generated using various construction strategies. The data input requirements and CSG tree size are dependent upon the modeling strategy only. These criteria may be used to measure the efficiency of the designer in creating a particular model as well as the relative complexity of models created using different construction strategies.

The data storage requirements are specific to this particular commercial solid modeling system. As such, the data storage criterion should serve only as an indication of what might be expected on similar systems and used for informational purposes only. It may also serve as a measure of the relative complexity or size of models created using different modeling strategies.

Surveys

In addition to the generation of solid models by members of this research team, selected parts were presented to students, engineers and designers in industry, and users of other solid modeling systems. These participants were asked to build one solid model of each part and report on the construction methods used. In addition, they were asked to supply

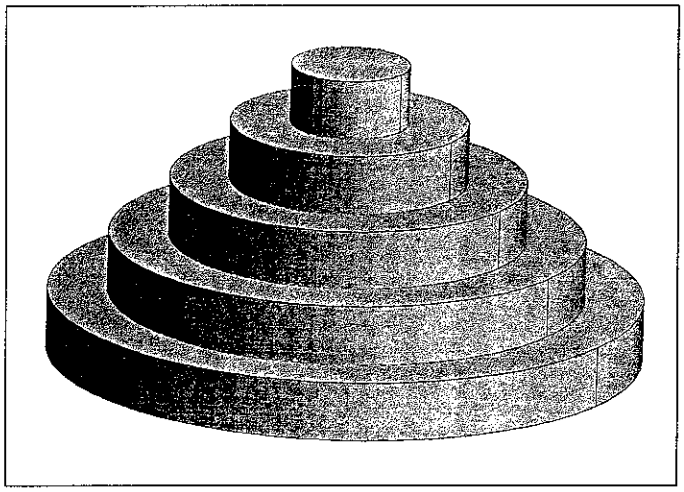

Figure 2. Part Number 2, Tower of Cylinders

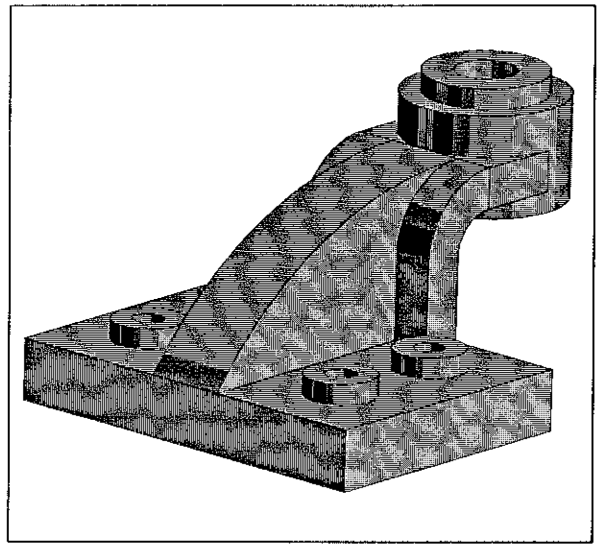

Figure 3. Part Number 3, Shaft Mount

a brief history of their background in engineering, design and CAD in an effort to determine how experience affects the choice of methods used to construct solid models.

Results

Parts

A variety of parts were selected for evaluation; four of these parts are described here. Part #1 is a simple cylinder. This part was chosen for basic analysis of construction methods since a cylinder can be constructed using numerous techniques including CSG, revolution, extrusion, skinning and sweeping.

Part #2 is a tower of five concentric cylinders of decreasing size as seen in Figure 2. The part has few entities and low level of complexity.

Part #3, a shaft mount, is shown in Figure 3. It has a relatively large number of primitives but with a low degree of complexity. It can be constructed using either CSG or Boundary Representation (revolution and extrusion) or a combination of these two.

The swivel bracket shown in Figure 4 is Part #4. It contains skinned solids which join the two arms of the bracket with the collar and a large number of entities. Thus, the part was an example of both a complex and large model. Since the skinned solids cannot be created using CSG methods, this part was used primarily for the user survey portion of the study.

Part #5 is a simple bracket, shown in Figure 5. It contains no complex entities but the number of entities is large (Category 3). The part is similar to Part #3 except that this part also requires rotations of either the construction plane or entities, which increases the level of construction complexity.

Evaluation of Part Construction

Several parts were evaluated using the data entry evaluation criterion. An attempt was made to explore all possible methods of construction for each component and collection of components. The method requiring the minimum amount of data input was used to normalize the data for each part to measure the data input efficiency of each construction method. Typical data from the evaluations are shown in Table I.

Data Input Requirements

The results of the data input evaluation of the parts can be summarized as follows:

1. The construction technique used to create the part strongly influenced the number of steps required. In the parts evaluated here, the increase in data entry ranged from 25% to 247% when data for each part are normalized to the

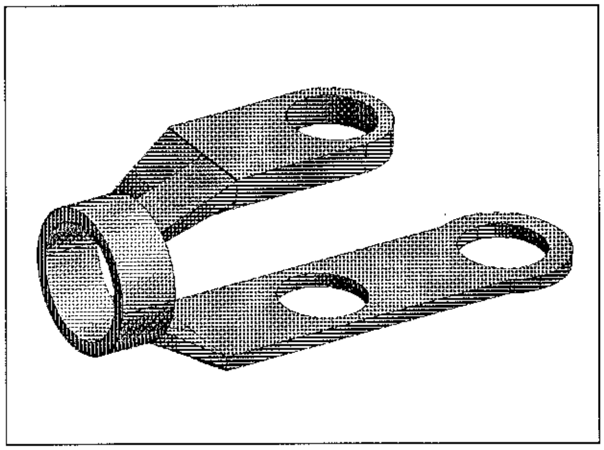

Figure 4. Part Number 4, Swivel Bracket

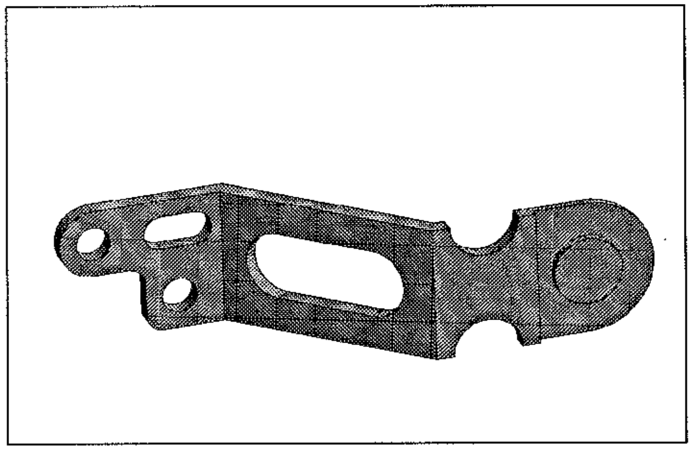

Figure 5. Part Number 5, Simple Bracket

method which requires the least input. If one assumes that on the average the amount of data entry is proportional to the amount of time spent to construct a part, selecting the most suitable construction technique can translate into significant savings in the construction time.

2. In general, CSG requires less data entry due to the symmetry inherent in the geometry of the primitives. However, for some the components or subsets of the geometry such as complex contoured solids, the user has little or no choice between different construction techniques.

3. Using the utilities and unary operations such as move/rotate axis, copy, mirror can contribute significantly to the savings achieved in construction time.

4. Using features to modify the model can contribute significantly to the savings in construction time. A limited number of parameters are necessary to specify these features which are combinations of simple primitives applied to the geometric model.

CSG Tree Evaluation

The following is a summary from the evaluation the CSG trees of the five parts:

1. The CSG tree is smaller for parts built using CSG methods. The large size of the CSG trees for extruded, revolute, skinned and swept solids can be attributed to the large number of entities required to specify profiles. If the profiles

PART	*Construction Method*	*Data Input*	*CSG Tree Size*	*Data Storage (bytes)*
1 Cylinder	CSG Revolution Extrusion	1.00 2.25 1.25	1 4 2	142366 105740 103266
2 Tower of Cylinders	CSG Revolution	1.00 1.19	6 12	297736 237724
3 Shaft Mount	CSG Revolution/ Extrusion	1.00 2.12	23 44	203138 240002
5 Bracket	CSG Extrusion	1.00 3.47	27 46	136316 119372

Table 1. Data Input Requirements for Solid Models

are counted as single entities, then the CSG trees of models made using b-rep methods would be more compact than those of the CSG models. Thus, the results reflect the "accounting" methods used in evaluating the trees.

2. The CSG tree is a very powerful and compact tool in visualizing the construction technique used to create a part. When a part is created using Boundary Representation, the tree appears very compact.

Data Storage Evaluation

Several observations can be made by comparing the data storage requirements of each model.

1. With the exception of the simple primitive cylinder, there is no apparent trend in the results. This indicates that there is a significant amount of overhead associated with the node operations (listed on page 17).

2. Studies were also performed to determine the effects of differences in the selection of tolerances for the faceted representations. These studies indicated that a substantial amount of the data storage requirement is due to the polygonalized model. The storage size of the model may increase by as much as 250% by building the model with a decrease in the facet tolerance by a factor of 10.

Survey Results

Three students, three industry employed engineers, and three university graphics instructors were asked to build models of various parts and report on the construction techniques used. All of the students and engineers used the same modeling system as was used by the authors in this study (Aries). The graphics instructors all used other solid modeling systems (AutoSolids and SilverScreen). The following observations were made based on their responses:

1. The background of the participants varied. All of the graphics instructors teach solid modeling in their curricula and have extensive experience with wireframe CAD and/or conventional drafting practice. The engineers also had CAD and/or drafting experience before their introduction to solid modeling. These individuals' preparation in solid modeling was largely self-taught, although one engineer had obtained instruction from the software vendor. One of the student participants had limited experience with a wireframe CAD system; all three students were instructed in solid modeling by the student authors of this paper.

2. Individuals with drafting or wireframe CAD experience preferred to use b-rep methods. In general, these construction techniques are not the most efficient. However, these methods are conceptually similar to the techniques used in conventional drafting.

Conclusions and Recommendations

The objectives of this study were to identify strategies for the efficient generation of solid models and concepts for teaching solid modeling. A limited number of parts were studied, and evaluated based on criteria which were related to the size and complexity of the model. On this basis, the following conclusions and recommendations are made:

1. The concepts of visualization and decomposition, boolean operations, interpolation and model uniqueness are suitable topics for instruction in solid modeling. CSG techniques using primitives and boolean operations appear to be the most efficient method for constructing parts. However, since there is little difference in model size for different construction methods, the use of CSG vs. b-rep methods may be chosen according to the designer's preference and software capabilities.

2. Parts with high geometric complexity (categories 2 and 4 above) were not considered in the evaluation phases of this study since they cannot be modeled using alternative methods. However, the concepts of blending and interpolation required for skinning and sweeping are necessary components in the curriculum. Advanced modeling strategies for these parts should be included in a basic solid modeling course, since many parts cannot be accurately modeled using simpler techniques.

3. The use of utilities and unary operations should be included in CAD instruction for both solid modeling and wireframe CAD systems. These utilities may greatly reduce the number of steps needed to create some parts.

4. There is no construction technique that "works" for every part. Therefore, it is important for the designer or engineer to become proficient with both CSG and b-rep methods.

Acknowledgements

This study is based on work conducted as a part of an Interactive Qualifying Project at W.P.I. The study was initiated by discussions at the NSF workshop on graphics at the University of Texas at Austin in May, 1990. The authors wish to acknowledge the contributions of Ms. Laneda Barr at the University of Texas at Austin, Prof. James Bolluyt at Iowa State University, Prof. Michael Stewart of the University of Arkansas, Messrs. John Fargo, Michael Carmen and David Baker at Bose Corporation, Mr. Shawn Harty and Ms. Marianne Kronenburg at Aries Technologies, Inc. and the numerous students at WPI who participated in the user survey. The reviewers have supplied many thoughtful comments which have helped to improve and clarify the discussion.

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Division News and Notes

Chair's Message

1992-93 EDGD Chair Vera Anand accepting a plaque from 1993-94 EDGE Chair Barry Crittenden.

Since this issue is so late in the year, Vera Anand, our 1992-93 Chair has officially relinquished the position to the 1993-94 Chair J. Barry Crittenden.

I would like to thank Vera for her time and energies over the past year. The 1992-93 year has gone smoothly and successfully.

Since Barry will take over this page with his remarks, starting with the Autumn issue, I would like to put a few words in of my own. I have every confidence that Barry will do a great job as Chair of the EDG Division. He is energetic and organized. He is interested in change as well as maintenance of the division.

One concern we have about the EDG Division is that our numbers have been dwindling. Since there are more and more people involved with graphics, especially now with the interest in CAD, our numbers should be going up rather than down. I would encourage each of you to do three things.

1. Make a list of those people you think might be prospective members of the EDG division. These people do not need to be engineers teaching at the university level. We will happily welcome anyone who is teaching or interested in graphics. This includes the community college as well as the high school level. Send their names and addresses to Linda Cleveland who is charge of membership for the division. She will contact everyone with information about the division.

2. Get involved in the EDG Division yourself. In the autumn issue we will publish a list of the committees and their chairs. I encourage you to find a committee that interests you and offer to serve as a member. Most committees do involve a huge time commitment, but they do offer you the opportunity to interact with division members.

3. If you have an suggestion, comments, or complaints, let us know. If you want to share your comments with the readership, send your letters to me, Mary Sadowski. Otherwise, send comments, etc. to Barry Crittenden.

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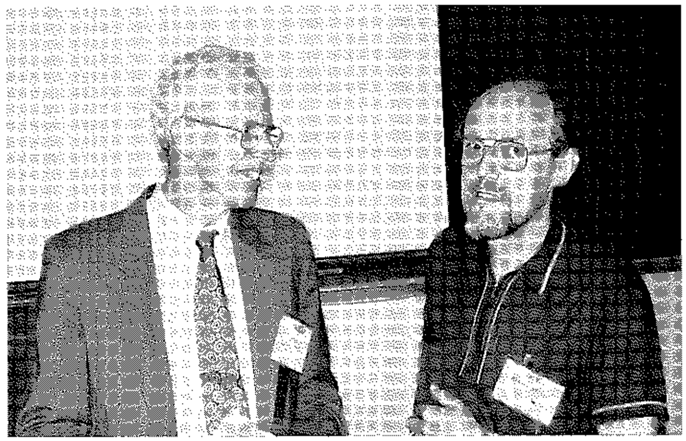
1893 ASEE 1993

SHAPING OUR WORLD – CENTURY II

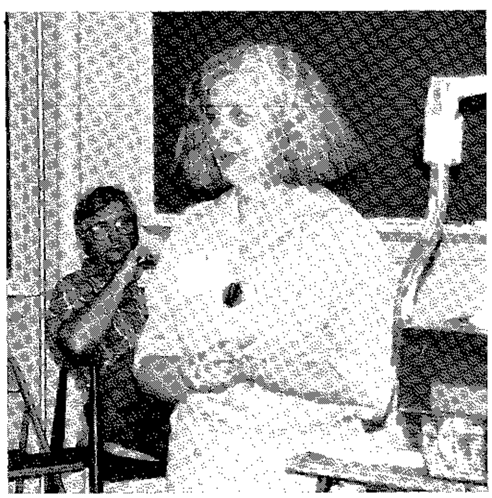
The ASEE Annual meeting at the University of Illinois was a huge success, and we should give a hearty thanks to Michael Pleck. He organized, intervened, guided, and generally took care of the major upsets as well as the minor glitches. Due to his input and time commitment, the EDG Division had several well-run and interesting sessions.

One of the announcements at the annual meets concerns the elections held this past spring. The results are:

Vice Chair:
William A. Ross
Director: Professional and Technical
Robert A. Matthews
Director: Zones Activities
Moustafa R. Moustafa



Jon E. Freckleton, Jr. and Brian J. Stone after their paper presentation on the use of Hypercard for geometric dimensioning and tolerancing training.



Lia Brillhard discussing her approach to solid modeling instruction. Session moderator Larry Goss watches.

Michael Pleck, EDG Technical Chair for the 1993 ASEE Annual Meeting at the University of Illinois.

1993 Distinguished Service Award

Presented to:
Mary A. Jasper

June 22, 1993
Champaign, Illinois
ASEE Annual Conference

Frank Croft, Mary Jasper and Larry Goss

Introduction by Frank M. Croft

I am honored to introduce this year's Engineering Design Graphics Division Distinguished Service Award recipient. It is my pleasure to inform you that this year's recipient is Mary A. Jasper from Mississippi State University.

I have known Mary for as long as I have been in ASEE. That's a total of 20 years. She and I have shared some very good times together over the past 20 years, and I'd like to relate to you some of the most pleasant memories I have had while associated with this division.

At the mid-year meeting of 1979 at Mississippi State, Mary was in charge of planning, operations, program, marketing, plant trips, and whatever else was needed. Mary got it done. I can still remember when we gave the opportunity like we gave Tim [Sexton] tonight — the opportunity to promote the meeting — Mary stood up in her best southern accent and said, "Y'all come!" And we came.

The meeting was in January and many of us snowbirds from the north were looking forward to going south and warming up. I recall that I drove over to Evansville and Larry [Goss] and I drove down together. It was pretty icy coming south and we thought the farther south we got that it was going to get better. It didn't.

I didn't even take a coat with me because I was expecting warm weather. At any rate, temperatures were hovering around 10 degrees. Pipes were freezing in the hotels. People were freezing. As a matter of fact, the only thing that made the trip pleasant, was that Ed Mochel rode back with us in the car to Memphis and kept us in stitches from the stories he told. Nevertheless, it was cold. Mary made us very comfortable with her warm southern hospitality. No one really noticed the cold while we were there. We enjoyed it very much.

Mary was elected editor of the Journal in 1979 for a three-year term. In the history of the division, there have been three women who were editors of the journal. The first was Mary Plumb Blade, the second was Mary Jasper, and the third is our present editor, Mary Sadowski. The reason I mention this is that in the election, Mary beat me! The funny thing was I didn't think that was possible. I thought I had a good chance of winning because I had spent three years as associate editor under Paul DeJon learning the ropes. I thought I was ready. I was talking to Amogene Devaney and she said, "Are you running for office?" I said, "Yes, I'm running for Director of Publications." She said, "Who are you running against?" I said, "Mary Jasper." She said, "That's too bad." Actually, that was too good because Mary was an outstanding editor of the journal and I had the privilege of serving with her for a year as associate editor and then as advertising manager.

I have to tell you about the imperial chicken. You may not think it's funny, but Mary and I think it's hilarious. Every time we get together, we talk about the imperial chicken. At the time we were at the International conference in Vancouver, gasoline in the States was selling for somewhere around 65 cents per gallon. As soon as you crossed the border into Canada and went to fill your tank up it was 85 to 90 cents per gallon. (They sold it in gallons then.) But people were sort of hoodwinked, they said, "Oh, that really isn't much difference in cost because gasoline is sold here by the imperial gallon which is slightly larger than the normal gallon we're used to." So that was the talk there, don't worry about the gas prices. It's not any more expensive than what you're used to in the States because you're buying it by the imperial gallon which is much greater.

I was into horse racing at the time since I was living in Louisville and Mary and I got together with Rosemae Westfall and got on one of the buses that went out to Exhibition Park to the horse racing track. We were tooling along laughing and having a good time and the bus pulled up to a traffic light and I looked across and see a butcher shop. The shop had a big advertisement in the window for frying chickens at $1.79 a pound. This was in 1978, and that was a little expensive. I called Mary's attention to it. I said, "Isn't that expensive for frying chicken?" Mary said, "Well, yeah that might be a little expensive."

"Oh, wait a minute, that must be imperial chicken."

I claim I said that. Mary claims she said it. But that was the evening the imperial chicken was born and every time we get together we reminisce about it.

I've had an awful good time with Mary over the past twenty years. I'm very pleased that she is the recipient this evening.

Introduction by Larry Goss

I'm going to give you some particulars about Mary's background.

She received a double baccalaureate in Civil Engineering and Business Administration from Mississippi State University in 1959.

She worked for the Mississippi State Highway Department from 1959 to 1961 and returned to graduate school in 1961 and received her masters in Civil Engineering in 1963. She worked for the US Army Corps of Engineers Waterways Experiment Station in Vicksburg in 1963, married Martin Jasper in November, 1963, and moved to Tuscaloosa where she became a temporary Instructor of Engineering Drawing at the University of Alabama, 1965. There she met Jack Brown.

She and Martin started their family of three girls and two boys, moved to Starkville, Mississippi, in 1966, and became a part-time Instructor of Engineering graphics at MSU in 1970 while some of the kids were still in diapers.

She has moved through the academic ranks over the years until now she is Professor and Coordinator of Engineering Graphics at Mississippi State.

She attended her first ASEE meeting as a participant in 1973, served on the EDGD design display committee, 1975-1979, and was EDGD Journal editor from 1979 to 1982.

Mary has chaired or made presentations at the mid-year or annual meetings since 1978. For several years our children met and socialized together at ASEE meetings and Rena and I would have dinner with Mary and Martin on Monday or Wednesday evenings during the annual conference. We shared her loss when Martin died suddenly in 1988.

Mary has been active in State Women in Science and Technology and Women Engineering Program Advocates Network and was named Woman Faculty of the Year at Mississippi State in 1977.

Both Mary and her oldest daughter are registered professional engineers, the first such mother/daughter duo in the state of Mississippi.

At the mid-year meeting in Tuscaloosa in November, 1989, I sat and talked with Mary in the lobby of the Paul Bryant conference center during one of our breaks. I showed her a copy of the book recently authored by my department chairman titled "Sons of Martha." The book is a collection of writings about engineers and engineering (particularly civil engineering) that has become a runaway best seller. The book takes its name from a poem by Rudyard Kipling which describes the hypothetical family life of the bibilical characters of Mary and Martha, sisters of Lazarus. You all know or have heard the story of the sisters and particularly of Martha's complaint that Mary wasn't helping her get dinner ready for Jesus and the disciples. Martha is depicted as the "shaker and mover" of the household. We as engineers are described by Kipling as the sons of Martha because we get things done.

Mary paged through the book and said, "I've got to have a copy of this. No, I need two copies." I said, "I'll see what I can do." In the four months the book had been on the market, the first printing had completely sold out, but I was able to scrounge up a couple of copies to send to Mary for Christmas. Two years later Mary called me up from the Mathison compound — You see, the Jaspers moved with all the kids to the suburbs and bought neighboring houses. They lived in a couple of them and used a third one for their consulting business. So there is a "Jasper compound" in Mathison — She was headed to Purdue for the Frontiers in Education conference in 1991 and wanted to stop by to see Rena and me. She entered our home in Evansville and said, "This is for you." It was a Mississippi State publication written by her and titled, "Martha's Daughters." It contains biographic vignettes of female engineers and their contributions to our technological society.

Mary, you are indeed proof that Martha had daughters as well as sons. It is with a great deal of pride that I am allowed to present the Distinguished Service Award to you.

The inscription reads:

Distinguished Service Award

Mary A. Jasper

Mary A. Jasper is hereby recognized by the Engineering Design Graphics Division of the American Society for Engineering Education for her outstanding contributions to the division and to engineering education. She has served the division in various capacities including director of publications. She has been an outstanding role model for young women in engineering and has been recognized as such by her peers. This award is the highest that can be presented by the division to one of its members. Mary A. Jasper has been selected for this honor by her colleagues for her outstanding career at Mississippi State University as an educator, scholar, and leader. Presented this day June 22, 1993, at the ASEE annual conference Urbana-Champaign, Illinois.

[Signed by] Vera B. Anand

Remarks by Mary A. Jasper

Well, Mike [Pleck], here we are in the heartland. It is written in the tomes of the Engineering Design Graphics Division somewhere, but only Bill Rogers and Larry Goss know where, that the recipient of this award is outstanding in the field of Engineering Design Graphics. Here we are in the heartland, and I'm out standing in my field.

I want you to know that my accent has gotten a little more cosmopolitan over the years, but it will probably come out sounding like pure corn pone sliced right down the middle. I want you to know that Mississippi has changed. In the copy of The Prism that everybody got in their [registration] packet, under "News from the Universities," the engineering research center at Mississippi State (of which we are really proud) is covered with a full page writeup. A member of our division said that this is a model program for engineering research centers for the whole United States. I had nothing to do with it, but it gives us some recognition.

We're really becoming less provincial all the time. When I go to work I have to travel 23 miles on a two-lane road. That's alright because every day I get to see the new road kill! Over the last several years the road kill has changed from the southeastern type of 'possums — You know, 'possums are just plain dumb, but they're not near as dumb as their southwestern cousins the armadillos — Now, you can count two or three armadillos on the side of the road going to work every day. So anyway, I have never never in my life felt more undeserving of anything that happened to me except when the twins were born in '64, and Theo was born in '65, and Mary Margaret was born in '67, and Bill was born in '68. Why me, Lord? But seriously, about receiving this award, I do feel undeserving and somewhat inadequate. The memories some of you have of the Engineering Design Graphics Division and the contributions which you have made to the division begin earlier and have much more texture and pattern than do my own efforts.

My first ASEE meeting was in Lubbock, Texas, in 1972. I shared this story with Judy [DeJong]. Her daughter, Deidre, taught my seven-year old twins how to pick up room keys from the bottom of the pool at the Lubbock Roadway Inn. Alice reminded me on the way up here that she nearly drowned and Deidre, in the best yankee hospitality that she could muster, found her a life preserver so Alice was able to go back into the pool later on.

In 1973, we took the whole family to Renssalaer. As Dean Emeritus Cooper from Purdue expounded on the evolution of Engineering Education, all five of my children were sliding down the bank right outside the open window of the RPI faculty club where the EDGD awards were being held that year. My husband left the banquet quite quickly, rounded all of the little buggers up, led them across the quad to the dorm and paddled them all profoundly.

". . . we must continue to acquire, to learn, and to teach the cutting edge of technology and computer graphics systems; hardware and software."

In 1974 we travelled to Ames, Iowa, for the ASEE meeting. We took our full grown collie — five kids, one collie, and two extremely nervous adults in a double-double at the Ramada Inn. As if that were not enough, as a kindness, the good Ramada Inn folks put all of the Mississippi delegation in the same wing and same floor of the Ramada Inn. We ended up next to the MSU dean of engineering, Harry Simeral, and his wonderful wife Mary Virginia, who had no children. The dog barked, the kids yelled, and I cooked pot roast in our room. As a family, we have gone to two midyear meetings in Louisville, we have camped in KOA in transit out of assorted vans and mini-vans. We've camped in state parks, we've camped in hotel rooms. But nothing was more incredible than hauling pubescent and prepubescent siblings up to UMass for a full array of family activities. Theo, my oldest son, traded off my watch for baseball cards. The twins were too shy to go the teen activities and Rena [Goss] can attest to the fact that they stayed in the room all day long watching soap operas. Bill, my finicky eater, learned to love fried clams and you know you can't get a fried clam in Mississippi.

I've been to plenty of ASEE annual meetings and mid-year meetings alone and to some accompanied only by my late husband, and believe me, I've always received much more in the way of friendship, camaraderie, and great ideas for the classroom than I could ever pay back with an occasional paper read or journal edited. Paraphrasing the comic, Garrett Morris, of Saturday Night Live fame, "The EDGD been very good to me."

We've come a long way together, the Engineering Design Graphics Division and I, from mechanical drafting, to computer-aided drafting, from ditto copiers and four-copy-per-minute xerography to laser printers. Remember if you will, constructing a geometric construction problem on a ditto master. And we've gone from batch processed computer graphics to interactive computer graphics. Now, some of you younger folks have never had the joy of writing code, punching cards, placing the cards in the card reader, and finally creating the perfect drawing over in another building on the campus. Or punching up a zillion computer cards, having to go through those cards to pull out a couple of mispunched data cards then having a student dump your card box on the way to the reader and having the zillion cards in no order at all all over the floor. Batch was a [black spot]. You know there wasn't much after drafting machines that they could do to a drawing board and T-square, but now, all of us are in a never ending battle to upgrade both hardware and software on a continually shrinking budget.

And what about our students? In 1970-72 most of my students were white males. Some of them even had drafting courses in high school. Now as we look at our computer graphics lab over the tops of the monitors, we see a more culturally diverse student population. The faces are more gender balanced. Today as teachers we not only have to master the new software and the hardware (when and if we're lucky enough to get both of them at the same time together), we also have to develop strategies for teaching the newer more improved student population. As I recently learned, different students have different learning styles. The old buzz words are still around; visualization, freshman team design, and even descriptive geometry. But now we add loop learning, critical thinking, and group study. You know, as teachers of engineering graphics (the language of engineering) we can do it. We can adapt to the new technology of learning as we have adapted to the new technology in tools. Consider this, our very presence at this august meeting of engineering educators in the year 1993 proves this point. You've already heard a little about the midyear of ice and snow in 1979 in the sunny South. I believe it was in Starkville, Mississippi, and we nearly froze our kapooties off. Some of the highlights were not mentioned by my introduction team. Klaus Kroner slipped on the ice crossing the street from the Holiday Inn to the steak house where we held the executive committee meeting. And the delegation from VPI, Bill Rogers and Bud Devens, found a black cat in their room at the Ramada Inn. I do believe that augured for a good meeting. But I digress.

One of the most controversial topics of discussion at the sessions at that midyear meeting happened to be "The Future of Traditional Engineering Graphics in the Engineering Curriculum." Some folk in ASEE and in ABET and in engineering administration around the country did not believe that engineering graphics as we taught it at that time had much of a place in the future of engineering education. If you older, greyer folk will remember, this was the time of the big purge. Many traditional departments of engineering drawing and engineering graphics were: 1) being merged with other engineering departments, 2) being transferred to other colleges and divisions, for example engineering technology education and sadly, 3) being eliminated altogether. Those of us that hung around (and did not retire) after the time of (dare I say it) "curriculum cleansing"; those of us who were left, learned to program. We learned to write code. Some of us learned DOS and some of us learned UNIX. Some of us bought Apples. Some of us bought IBM PC's. Some of us bought TRS-80's which had no graphics at all. But we all came into the computer age (some of us kicking and screaming as it were) and along the way we picked up some very capable and intellectual minds; those of you who are assembled here.

We found out that it really does not matter where the discipline of engineering graphics is located, as long as the folks who teach it are performing the traditional function of teaching future engineers and technologists alike to read and write the language of engineering. We found that the teaching of engineering graphics is not tied to the tools of implementation. We can use pencils, pens, or magic markers. We can use straight edges, or T-squares, or nothing at all. We can use vellum, we can use quadrille paper, or we can use paper napkins. And we can use mechanical or electronic devices. We have obtained (by fighting for it tooth and nail in some cases) a new credibility. But a word of caution (before we squash our laurels by resting on them). To maintain this credibility, we must continue to acquire, to learn, and to teach the cutting edge of technology and computer graphics systems; hardware and software. We must continue to provide customer service as modern as our customers (both industry and our graduates) require. We must continue to act and teach in the most professional manner possible in order to attract the best of our students into the profession we have found so rewarding. To maintain this credibility among our learned colleagues, we must be every bit as learned. We must be every bit as excited about our subject, the language of engineering, as our learned colleagues are about their disciplines.

We must learn to teach to the different learning styles of our changing student population. In the new dichotomy of science,

engineering, and math education (and I know Arv [Eide] and Rollie [Jenison] have heard this a lot) the term "gatekeeper courses" is spoken quite often. We don't need to have engineering graphics, the beginning course, be one of these gatekeeper courses. If we have taken for granted that our students know what a spring, nut, vise, or screw is, let us not forget that each of these terms have various meanings in everyday life.

We must become less parochial and possessive about computer graphics applications, and more ready to accept, yea even to seek out, interdisciplinary collaboration. I've said it many times before, what the general public knows about engineering can usually be placrd in a thimble. In fact, if we didn't have negative PR, we wouldn't have any PR at all. When we tell folks we teach engineering graphics, or engineering design graphics, or heaven forbid, computer graphics, and we receive in return, a blank stare, what are we to do? The solution to this problem is to come down from our ivory towers and to mix and mingle with the masses. We know this intuitively. We've known it for a long time but we still need to practice the style in order to become skilled in the use of it. We need to learn how to blow our own horns. Folks, we have the product everybody wants; computer graphics. We need to advertise it.

So there you [have it]; the advice of an old grey-haired woman, who if the good Lord is willing, will see this division into the twenty-first century. And here we are in the heartland. Thank you all for making me outstanding in my field.

EDGD Five-Year Plan

Submitted by Barry Crittenden, 1993 - 1994 Chair, EDGD

1993-98
EDGD 5-Year Plan Proposals

A request for suggestions for the EDGD 5-year plan resulted in 20 proposals, presented at the Mid-year Conference at the EDGD held in San Francisco, CA in January 1993 (list attached). A suggestion was made to assign the various tasks to existing directorates, committees and individuals in the Division. The Vice-Chair agreed to pursue this suggestion.

The task of assigning responsibility for the various tasks led to the conclusion that we must prioritize these tasks, suggesting to the directorates, committees, and individuals the order in which they might tackle the problems assigned to them. Three levels of prioritization are suggested, defined as follows:

Level 1 - immediate action should be initiated
- possibly affects the entire division membership
- possibly affects the EDG curriculum

Level 2 - initiate action within two to three years
- possibly affects a large percentage of the membership

Level 3 - initiate action within three to four years
- possibly affected by Level 1 and 2 actions

The twenty tasks are listed in abbreviated form below in a suggested priority order. Following the task number is the directorate, committee, or person suggested to handle the task.

LEVEL 1

Task 1 - *Three immediate past Division Chairs*, the *present Chair*, & the *Vice-Chair*
Pursue ABET recognition.

Task 2 - Director: *Zones Activities Committees* &
Director: *Liaison Committees*
Develop and implement a systematic means of increasing membership.

Task 3 - Director: *Professional and Technical Committees*
Establish a research agenda.

Task 4 - Director: *Programs*
Revive the EDGD Summer School.

Task 5 - *Individual Directors*
Establish goals for standing committees.

Task 6 - *Executive Committee*
Establish a statement of five-year goals.

LEVEL 2

Task 1 - Director: *Liaison Committes*
Develop and implement a plan to increase industrial contacts.

Task 2 - Director: *Liaison Committees*
Plan for lobbying activities on a continuous basis.

Task 3 - Director: *Professional and Technical Committees*
Seek EDGD representation on ANSI standards committee.

Task 4 - Director: *Professional and Technical committees*
Establish an EDGD paradigm.

Task 5 - Director: *Professional and Technical Committees*
Prepare a curriculum model.

Task 6 - *Ed Boyer* &
Director: *Publications*
Reprint the EDGD Directory.

LEVEL 3

Task 1 - Director: *Programs* &
Director: *Professional and Technical Committees*
Develop a policy and guidelines for accrediting engineering graphics programs and instructors. (Accreditation of instructors might be an EDGD Summer School goal.)

Task 2 - Director: *Professional and Technical Committees*
Establish special interest groups.

Task 3 - Director: *Liaison Committees*
Establish a description of graphics influence on product development.

Task 4 - Director: *Liaison Committees* &
Director: *Programs*
Interact to a greater extent with other ASEE divisions.

Task 5 - *Executive Committee*
Encompass a broader range of members in leadership roles.

Task 6 - Director: *Publications*
Prepare a list of member professional interests.

Task 7 - Director: *Publications*
Prepare a *Journal* financial plan.

Task 8 - Director: *Professional and Technical Committees*
Define terms used in engineering design graphics.

1993-94 48th EDGD Mid-Year Conference

Ohio University, Athens, Ohio

October 31 - November 2, 1993
The Ohio University Inn
331 Richland Ave.
Athens, OH 45701

american society for engineering education
engineering design graphics division

Keynote presentation

Dr. John Gephart of InterCAP Graphics Systems.
Dr. Gephart will speak on CALS Graphics. CALS in an acronym for **C**omputer-**A**ided **A**cquisition, and **L**ogistical **S**upport.

Paper and poster sessions

Workshops:

Design and Production of Presentation Graphics
Judy Birchman and Jon Duff
Technical Graphics
Purdue University

From CAD to CAM to Actual Part Production
John Deno,
Industrial Technolody
Ohio University

Geometric Dimensioning and Tolerancing,
Pat McQuistion
Industrial Technology
Ohio University

These are hands-on workshops which will be offered on Sunday October 31. They will be conducted at the College of Engineering and Technology of Ohio University.

Spouses Program:

The activities planned for spouses include a tour historical Marietta, Ohio, Fenton Glass, the Middleton Doll Factory, The Dairy Barn Cultural Center, and local artist studios.

General Chair
Tim Sexton
College of Engineering and Technology
Ohio University
122 Stocker Center
Phone: 614-593-1459
Fax: 614-593-4684
e-mail: sexton@dolphins.ent.ohiou.edu

Program Chair
J. Doug Frampton
Engineering & Technology Division
The University of Akron
120 Schrank Hall South
Akron, OH 44325-6104
Phone: 216-972-5139
Fax: 216-972-5300
e-mail: jdframpton@vax1.cc.uakron.edu

ASEE & EDGD Programs

Prepared by Del Bowers
EDGD Director of Programs

1993-94 EDGD
48th Mid-Year Conference
Athens, Ohio
October 31-Nov 2, 1993
Host: Ohio University
General Chair: Timothy J. Sexton
Department of Industrial Technology
122 Stocker Center
Ohio University
Athens, Ohio 45701-2979
(614) 593-1459
Program Chair: Doug Frampton
University of Akron
(216) 972-5139
FAX: (216) 972-5300

american society for engineering education
engineering design graphics division
1928

1994 Annual ASEE Conference
June 26-29, 1994
Edmonton, Alberta, Canada
Program Chair: Frederick D. Meyers
Department of Engineering Graphics
The Ohio State University
2070 Neil Avenue
Columbus, OH 43210-1275
Phone: 614-292-1676
Fax: 614-292-9021

See CALL FOR PAPERS page 40 this issue.

1994-95 EDGD
49th Mid-Year Conference
Location: to be named
Host: to be named

CALL FOR PAPERS

Sixth International Conference on Engineering Computer Graphics and Descriptive Geometry

August 19-23
Tokyo, Japan

Co-sponsored by the Egineering Design Graphics Division

TOPICS

Theoretical Graphics
Descriptive Geometry
Computer-Aided Design
Computerized Descriptive Geometry
Graphics-Oriented Expert Systems
Scientific and Technical Visualization
Engineering Animation
Image Processing and Remote Sensing
Graphics Teaching and Exercises
Computers in Engineering Graphics Education

DEADLINE: Submit paper title and 250-word abstract by October 17, 1993.

CONTACT: Rollie Jenison,
Iowa State University
206 Marston Hall
Ames, Iowa 50011

FAX: 515-294-4007

Calendar of Events

Prepared by Dennis R. Short

EDUGRAPHICS '93
First International Conference
on Graphics Education
Hotel Alvor Praia Alvor Algarve
PORTUGAL - 6-10 December 1993

Co-Chairs:
- Americas:

VERA B. ANAND, Clemson University, USA
- Europe/Rest of the World:

HAROLD P. SANTO,
Technical University of Lisbon, Portugal
Chair of Program Committee:
HAROLD P. SANTO,
Technical University of Lisbon, Portugal

COMPUGRAPHICS '93
Third International Conference on
Computational Graphics and
Visualization Techniques
Hotel Alvor Praia Alvor Algarve
PORTUGAL - 6-10 December 1993
Organization, Conference and
Program Committee Chair
HAROLD P. SANTO,
Technical University of Lisbon, Portugal

These conferences will be held concurrently and aim at gathering together outstanding educators, professionals and researchers in Graphics which will give keynote lectures or present papers reviewing, presenting a state of the art, discussing future directions or reporting new results on their fields. It will be open to contributors from all ranks and from all over the world. The conferences will not be merely 'computer graphics' meetings but truly all-encompassing events on all aspects and sub-areas of Graphics.

Topics include:
Technical Drawing, Engineering Graphics, Descriptive Geometry, Theoretical Graphics and Classical Geometry, Computational Geometry, Geometric Modeling, CAGD, Computer and Computational Graphics, Image Synthesis and Processing, Art, CADD, CAI, CAD/CAE, CAAD, GIS, Industrial and Engineering Design, Finite Element and other Numerical Methods, Artificial Intelligence and Expert Systems, Scientific Visualization, Standards, Human-Computer Interface, Physically-based Modeling, Animation, Natural Scene Simulation and Fractals.

For further Information:
Harold P. Santo
Department of Civil Engineering
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Av. Rovisco Pais, 1
1096 Lisboa Codex PORTUGAL
Tel. + Fax : +351-1-848-2425
E-mail : d1663@beta.ist.utl.pt
Submit abstract by September 17
Notification of Acceptance : October 15
Final Manuscripts : November 12

Please contact the Program Committee Chair for details about paper and panel submissions.

9th European Workshop on
Computational Geometry CG '93
March 18-19, 1993, Hagen, Germany
The goal of the Workshop is to bring together the European researchers in Computational Geometry.
For further information:
Christiane Banisch
Fern Universitat Hagen
Praktische Informatik VI
Elberfelder Str. 95
D-5800 Hagen 1

ED - MEDIA '94
World Conference on Educational
Multimedia and Hypermedia
New Streams: Distance Education &
AI in Education
June 25-29, 1994
Vancouver, Canada

Major Topics:
Authoring, Navigation, Language Learning, Learning by Doing, Media in Education, Pedagogical Issues, Hypermedia Systems, Hypermedia Applications, Small Dedicated Applications, Improving Classroom Teaching, Interactive Learning Environments, Computer Supported Cooperative Work, Novel Applications, Approaches & Ideas, Distance Education, Artificial Intelligence in Education
Submit to:
Ivan Tomek c/o AACE
P.O. Box 2966
Charlottesville, VA 22902 USA
E-mail: AACE@virginia.edu
Phone: 804-973-3987; Fax: 804-978-7449
Submissions due: October 22, 1993

First ACM International Conference on Multimedia
(co-located with SIGGRAPH 93), (SIGBIO, SIGCHI, SIGCOMM, SIGGRAPH, SIGIR, SIGLINK, and SIGOIS)
August 1-6,1993,
Anaheim, California,
For further information:
SIGGRAPH 93 Conference Management
401 North Michigan Avenue,
Chicago IL 60611

First Eurographics Workshop on Virtual Environments
Advances in Research & Applications
Barcelona, September 7, 1993
Polytechnical University of Catalonia, Barcelona, Spain
Avda. Diagonal 647, Barcelona 08028
For further information:
Danielle TOST
Email: dani@lsi.upc.es
Universitat Politechnica de Catalunya
Dept de Llaguatges i Sistemes d'Informatics
Seccio d'Informatic Grafica
Av. Diagonal, 647, planta 8, (edifici ETSEIB)
E-08028 Barcelona - Spain
Tel (3) 401 66 67 - Fax: (3) 401 66 00

Visualization '93
October 25-29, 1993
Red Lion Hotel
San Jose, California
Sponsored by: IEEE Computer Society Technical Committee on Computer Graphics in Cooperation with ACM SIGGRAPH.
Scientific visualization is an important research frontier shared by a variety of computational science and engineering fields. Visualization work is both interdisciplinary and a field in its own right. This conference focuses on interdisciplinary methods and supports collaboration among the developers and users of visualization methods across all of science, engineering, and commerce.
For further information:
Gregory M. Nielson
Arizona State University
Rural Rd and University Ave.
Tempe, AZ 85287-5406
nielson@enuxva.eas.asu.edu
602-965-2785

SIGGRAPH '93
August 1 - 6, 1993
Anaheim, CA
For further information:
312-321-6830

HCI INTERNATIONAL '93
5th International Conference on Human-Computer Interaction
jointly with
9th Symposium on Human Interface (Japan)
August 8-13, 1993
Hilton at Walt Disney World Village
Orlando, Florida, USA
For further information:
Gavriel Salvendy, Conference Chair
HCI International '93
School of Industrial Engineering
Purdue University
1287 Grissom Hall
West Lafayette, IN 47907-1287 USA
Telephone: 317-494-5426
Fax: 317-494-0874
Email: salvendy@ecn.purdue.edu

Virtual Reality Vienna `93
International Symposium on Virtual Reality and on New Technologies in Computer Simulation
December 1-3, 1993
Marriott Hotel, 1010 Vienna
The symposium offers the opportunity to attend discussions and present and to respond to papers about Virtual Reality (VR) and closely related fields. Participants will also have the opportunity to test VR-Systems.
For further information:
1AA Management Consulting GMBH
Schottenfeldgasse 51
1070 Vienna, Austria
Tel +43 / 222 / 526 57 48
Fax +43 / 222 / 526 57 49

1994 IEEE International Conference on Multimedia Computing and Systems
February 21-25, 1994,
Darmstadt, Germany
For further information:
Scott M. Stevens
Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15313 U. S. A.
email: sms@sei.cmu.edu
Phone: +1 412 268-7796
Fax: +1 412 268-5758

Washington Interactive Multimedia '93,
August 25-27
Washington, D. C.
For further information:
800-457-6812

Book Review

Engineering and the Mind's Eye

Ferguson, Eugene S. (1992) *Engineering and the Mind's Eye*. MIT Press: Cambridge, MA.

Reviewer: Eric N. Wiebe
North Carolina State University

It seems appropriate that in this 100th anniversary year of the ASEE that *Engineering in the Mind's Eye* by Eugene S. Ferguson would be published. Being a graphically oriented person, I very much wanted to read a book that set out, as its goal, to clarify the role of non-verbal thought in engineering over the last 500 years.

Eugene Ferguson, a professor of history emeritus at the University of Delaware, takes us on a richly illustrated journey through the development of the engineering profession in a concise 234 pages. Rather than bog down the text in minute of any one discipline or historical figure, brief vignettes are given of various episodes purely in support of his central themes. Where a more detailed description or support of an argument is warranted, the last 40 pages of the text is devoted to notes and citations of both the text and figures. This text makes for appropriate reading in undergraduate courses (which I am doing) while still containing the substance to be resource material for research.

The book retains a tight focus on the central theme of the book: the experiential and empirical aspects of engineering design. Ferguson makes his bias very clear from the outset. Beginning in at the end of World War II and continuing to this day, engineering as a profession has turned its back on nonverbal learning and nonverbal understanding in favor of the "high sciences". Those elements that cannot be expressed in a pure mathematical or scientific relationship has consistently been de-emphasized in the undergraduate curriculum. The result has been undergraduate engineers who are well prepared to go to graduate school in engineering and the sciences to do basic research but are ill-prepared to be practicing engineers in the field — the historic center of the profession. The rise of the engineering technology degree is explained as a response of industry to their need for technical staff prepared to handle the day to day job of developing, maintaining, and evolving current technology.

The book begins with an exposition on the nature of engineering design. At the heart of the design process is the conversion of one's vision in the *Mind's Eye* to a final product. Drawings have historically fulfilled this role along with physical prototypes. The roots of the engineering profession begins with artisans who created objects directly from the idea. Engineers developed intermediate steps, largely graphic in nature, which were used to test and refine the ideas. Both artisans and engineers have a number of things in common: for one, they both start with a 'blank page' and both draw on deep, tacit knowledge to guide them in the design. This knowledge can only be gained through experience; both experience with the materials and methods used in the final fabrication of the design, but also in the largely graphic process of developing the design.

Through the Mind's Eye reveals itself in a tangible form mainly through graphic means it is, in fact, the culmination of experiences through all of the senses, not just the visual. Experience fills the minds eye, allowing you to 'see' things others can't. Even though visual thought has low academic status, the beginning engineer can learn a lot from those that do have vision. This includes the skilled workmen who work with the materials and processes day in and day out.

The middle of the book devotes a large section to the origins of modern engineering beginning in early Renaissance times. A rich selection of figures traces the evolution of the profession from Italy to France and then, finally, to the United States. Though there are the prerequisite illustrations from

Leonardo DaVinci, there are many other early artist-engineers featured as well. There is a focus on the illustrated notebooks that all of the figures of this time used. These graphic texts were a important source of knowledge transference from one generation to the next. It is noted many of the designs in DaVinci's notebooks were, in fact, copied from earlier notebooks. This was the accepted mode of transferring the beginnings of engineering knowledge.

As engineering matured as a profession, so did the tools used in teaching and in the field. Beginning with the introduction of perspective projection to the development of parallel projection techniques, drawing evolved into a formal means of communication. The sketch, the original tool of the Renaissance, has never lost its place in the engineer's repertoire. It is still a principle tool for linking the Mind's Eye with the tangible end product. Equally important to the training of engineers was models. Many of the early engineering schools contained rooms of models demonstrating basic principles and mechanisms of the profession. Though not as quick to produce as a drawing, "A model can take an observer one step closer to reality than can a drawing"[1].

The later portion of the book details how government policies during and following World War II made it clear that science, not engineering — as it was traditionally practiced — was going to reign supreme. It was the National Science Foundation (not a National Engineering Foundation) born after the war. The NSF and military research organizations such as the Office of Naval Research set the tone for the academic community by funding pure science research at the elite universities. The Grinter report in 1952, sponsored by the ASEE, informed those who did not already know that the way to gain prominence for your program was to phase out skill and experiential curriculum, including engineering drawing and shop courses, in favor of the six engineering sciences.

Engineering graphics is closely tied to the tools of the trade. Unfortunately, the rapid evolution of tools used in practice has not paralleled an evolution as how graphics is viewed from within the profession. Ferguson worries that many too many think that CAD stands for Computer *Automated* Design not Computer-*aided* Design. That producing drawings on the computer somehow gives the drawing instant authority. That the neat clean look of computer generated documents matches the neat clean answers students get when solving their math equations. Deep, tacit knowledge only comes from verbal and non-verbal experience, not from running equations through a computer.

Ferguson takes a somewhat dim view of new technologies. I strongly get the suspicion that he would prefer a return to slide rules and nomographs. I agree that all too often failures in design are written off to not having the access to the latest and greatest technology just around the corner. At the same time, the lessons of what sits at the core of good engineering design can be used to reign in and focus the new technology. The increasing power of CAD systems means that no only can we draw on the computer, but we can also model. These were pointed out as the two central tools in successful design. Virtual Reality has been called a technology without a cause. It can be given central role in enhancing the nonverbal experience of both the student and practicing engineer.

One thing is for sure, these are not the types of tools that you just throw at the student and tell them to learn on the own. Practical hands-on experience, whether it is with eyephones and datagloves or a metal lathe, has to be a central part of an engineers experience. Our division has continued to devote itself to demonstrating how graphics can play a central role in the experiential education of students. Ferguson has given us a book that adds to the foundation of our arguments.

1. Ferguson, Eugene S. (1992) *Engineering and the Mind's Eye*. MIT Press: Cambridge, MA, p106.

Dear Editor:

As a former member of the Engineering Design Graphics Division and one of its past Chairmen, I wish to submit the attached material for possible publication in the Division' Journal. The work is original and as far as I know it is the first graphical representation which depicts the simple relationship between an arbitrary acute angle and one which is three times its magnitude.

This not say that others have not presented the problem as I have, but it does say that I am not aware of any previous work which this would seem to duplicate.

This is the first of a number of possible articles which may come later form this effort. I am waiting to get a new program on the computer for further study. There is much more to be said on this subject when the work involves a regular tetrahedron of which the equilateral triangle shown here is its base. I want to present this to the public and see what the response will be.

Even though the problem of trisecting an arbitrary acute angle, using only an unruled straight edge and a compass, has been around for centuries and many eminent mathematicians have proved it cannot be done: none have shown the relationship as this article does. This is the nearest graphical approach that I have ever seen.

Sincerely yours,

Dr. Clarence E. Hall, Professor Emeritus
Louisiana State University

The Equilateral Triangle

C. E. Hall, Professor Emeritus
Louisiana State University

The potential utility of the equilateral triangle continues to amuse mankind as a problem-solving tool. The following design presents the unique geometrical relationship of an angle (q) with (3 q). The various trigonometric equations which express this relationship are:

$$(1)\qquad Tan 3\theta = \frac{Sin(3\theta)}{Cos(3\theta)} = \frac{Sin(2\theta+\theta)}{Cos(2\theta+\theta)} = \frac{4Sin(\theta)Sin(60-\theta)Sin(60+\theta)}{4Cos(\theta)Cos(60-\theta)Cos(60+\theta)}$$

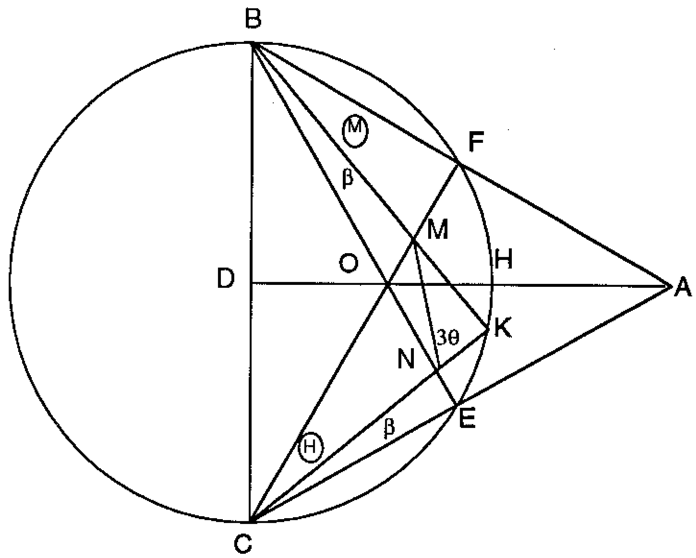
$$(2)\qquad Tan(3\theta) = \frac{Sin(\theta)Sin(60-\theta)Sin(60+\theta)}{Cos(\theta)Cos(60-\theta)Cos(60+\theta)}$$

This same function may be reduced to the following:

$$(3)\qquad Tan(3\theta) = \frac{3Sin(\theta)-4Sin^3(\theta)}{4Cos^3(\theta)-3Cos(\theta)} = \frac{Sin(\theta)(3-4Sin^2(\theta))}{Cos(\theta)(4Cos^2(\theta)-3)}$$

Given an equilateral triangle ABC with medians AD, BE, and CF. With point D as center and radius DB, construct the semicircle BFEC intersecting median AD at H.

Choose some arbitrary point K on arc HE and draw lines KB and KC intersecting median CF at M and median BE at N. Label angles MCK and MBF as theta. Label angles KCE and MBN as beta.



(4) $(\theta+\beta)=30°, or \beta=(30°-\theta)$, and $\angle CBK=(60-\theta), BC=S$

(5) $KB=S*Cos(60-\theta)$, and $KC=S*Sin(60-\theta)$

(6) Construct line MN, $\angle MNK=3\theta$

Proof:

(7) $KC=S*Sin(60-\theta), KM=KC*Tan(\theta)$, or $KM=S*Sin(60-\theta)*\frac{Sin(\theta)}{Cos(\theta)}$

(8) $KN=KB*Tan(\beta)$, or $KN+S*Cos(60-\theta)*\frac{Cos(60+\theta)}{Sin(60+\theta)}$

(9) $$Tan(3\theta)=\frac{KM}{KN}=\frac{S*\frac{Sin(\theta)}{Cos(\theta)}*Sin(60-\theta)}{S*Cos(60-\theta)*\frac{Cos(60+\theta)}{Sin(60+\theta)}}$$

Which reduces to,

(10) $$Tan(3\theta)=\frac{Sin(\theta)Sin(60-\theta)Sin(60+\theta)}{Cos(\theta)Cos(60-\theta)Cos(60+\theta)}$$

Equation 10 is the same as equation 2 which is proof that angle MNK is three times the value of angle MCK. Therefore, by selecting any arbitrary point K on arc HE and constructing KB and KC establishing points M and N, and line MN, then angle KOM is one-third of angle KNM.

As is quite obvious from construction, both q and 3q are formed simultaneously, even though point K was chosen arbitrarily. To the best of the author's knowledge this illustration depicting graphically the relationship between angles 3q and q is the first such illustration produced using only an unruled straightedge and compass in the history of mathematics. If not, when and where was an earlier one published?

Call for Papers

ENGINEERING DESIGN GRAPHICS DIVISION
1994 ASEE ANNUAL CONFERENCE
EDMONTON, ALBERTA, CANADA
JUNE 26-29, 1994

Papers are solicited which address the following questions:

- Are we teaching traditional graphics or the first course in engineering and design?
- What standards should we have for presentation materials in the classroom and meetings?
- Is graphics still needed in an engineering curriculum?
- What are the optimum qualifications for a graphics course?
- Should we include concepts of manufacturing-across-the-curriculum in our graphics courses?
- What is optimum coverage of topics . . . do we teach solid modeling, conventional descriptive geometry, or what topics in between?

Please send your abstract of not less than 100, nor more than 300 words, to the chairman named below **not later than September 8, 1993**. You will be notified by September 15 if your proposed paper can be included in the program. If included, completed papers must be submitted for editorial review **not later than December 8, 1993.**

Frederick D. Meyers
240 Hitchcock Hall
2070 Neil Avenue
Columbus, OH 43210-1275
Phone: 614-292-1676
FAX: 614-292-9021

NATIONAL DESIGN GRAPHICS COMPETITION

Date: 6-30-93

Dear Colleague,

On behalf of the sponsoring divisions from the American Society for Engineering Education (ASEE), I want to invite you to submit student design projects for the National Design Graphics Competition. This event will be held in conjunction with the 1994 ASEE Convention, June 26-29, 1994, at Edmonton, Alberta, Canada.

Please find the enclosed guidelines and registration forms for this event. These documents should answer most of your questions. Before entering the competition, please have the students make copies of their work. It is also appropriate to consider the inclusion of "Patent Pending" or "Patent Applied For" indications on their designs.

The competition has one specific project for all contestants. It is hoped that this will not deter any students from participating, but focus attention on the design of a product that is genuinely needed.

The graphic part of the project is a major component of the competition. The graphics should represent a chronological graphic record of the project. The graphics package should augment the technical report to form a complete design effort.

In addition to the competition there will be a display of student projects. The display is not a part of the competition.

Please note that the competition is open only to Freshmen students. The intent of this competition is to emphasize the importance of the design process early in the career of new engineering students.

I look forward to many interesting design solutions and hope to see you in Edmonton.

Sincerely,

Patrick J. McCuistion, Chairman NDGC

P.S. Several vendors have been approached to support this contest with software, hardware, and funding. None of them have committed in writing at this date. However, from their verbal commitments, there should be attractive prizes in all award categories.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION	SPONSORING DIVISIONS	ENGINEERING DESIGN GRAPHICS FRESHMAN PROGRAMS DESIGN IN ENGINEERING EDUCATION

IV. Entry Fee:

An entry fee of $10.00 (U.S.) must accompany each Registration Form. Please send checks or money orders only.

V. Project Team/Entry Limitations:

A. The maximum number of students per project is 4. All students must be classified as Freshmen by their respective schools at the time of submission of the Registration Form.

B. The maximum number of entries per school is 3. (A branch of a main campus is considered a separate school.)

VI. Judging:

Judging will be based solely on the items listed in sections I - V. Each project will be judged by at least three judges. Judging will be completed on Sunday morning prior to the start of the conference.

VII. Awards:

First, Second, and Third place awards will be given. Each student on an award wining team will receive an appropriate certificate. All other entering students who did not win will receive certificates of participation. The representative award winning schools will receive plaques.

VIII. Display Location and Schedule:

Location:	Edmonton Exhibition Hall
Set-up:	June 26, between 1:00 p.m. and 4:00 p.m.
Display hours:	10:00 am - 5:00 June 27 - 28
Removal:	June 29 between 8:00 a.m. and 10:00 a.m.

IX. Display contents:

The displays must include the written report and the graphics. The displays may utilize any additional medium of communication but all items must fit on table space no larger than 36" wide X 30" deep.

X. Project Interest and Registration Forms

Please find the enclosed entry forms. The Project Interest Form must be received no later than February 1, 1994. The Registration Form for each design team must be received no later than April 1, 1994.

Please direct questions to:

Patrick J. McCuistion
120 Stocker Center
Ohio University
Athens, OH 45701-2979
FAX # 614-593-4684
e-mail mac@cubix.ohiou

AMERICAN SOCIETY FOR ENGINEERING EDUCATION — SPONSORING DIVISIONS — ENGINEERING DESIGN GRAPHICS, FRESHMAN PROGRAMS, DESIGN IN ENGINEERING EDUCATION

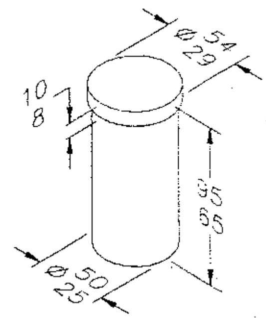
NATIONAL DESIGN GRAPHICS COMPETITION

1994 COMPETITION GUIDELINES

The National Design Graphics Competition (NDGC) will be held June 26-29, 1994, in Edmonton, Alberta, Canada, in conjunction with the American Society for Engineering Education (ASEE) Annual Conference. Projects entered that do not meet the following guidelines will not be judged. In addition to the competition, a display of the entries will also be held.

I. Design Project:

The project is to design a Medicine Bottle Opener. The device should open and close the type of pill container that requires a downward pressure while turning to open. This product will be sold primarily to persons who lack the hand strength or muscle coordination necessary to open such containers. The device must operate with minimum human intervention. Refer to the Figure at the right for minimum and maximum size constraints of the pill container (dimensions are in millimeters).



II. Project Contents:

Each project entry should contain the following listed items. The possible point value for each part of the entry is noted after the description. The total points accumulated will be used to determine the winners. Three copies of the abstract, written report, and all graphics must be submitted for each entry.

A. Title and Abstract Page: An 8.5" X 11" title and abstract page (on white paper) will accompany each report. It must include the project title, school name, names of participating students, date completed, estimated time to complete, and an abstract of no more than 250 words. The type font should be no less than 12 point size. 10 points

B. Written Report: The written report will be type written on no more than 10 - 8.5" X 11" white paper pages. The print will be double spaced, on one side only, be 10-12 point font size, and not encroach on 1" borders on all four sides of each page. The report is a segmented narrative that completely describes the activities of the team members in the following areas: 1) Problem Statement, 2) Preliminary Ideas, 3) Refinement, 4) Analysis, and 5) Final Solution. Each section is worth 15 points. (85 points total)

C. Graphics: A chronological graphic record is an integral part of this competition. Pertinent graphics are required for each phase of the design project, except for the Problem Statement (see part B). The graphics should range from concept sketches to final detail and assembly drawings. Each graphic must include a minimum of a title, date, and name of the person who created it. The graphics must be on paper. The total points for all graphics is 100.

D. Additional Scoring: Creativity and the Presentation Quality of the entry are worth 20 points each.

III. Submission date and time:

All project entries must be submitted to a NDGC representative at the ASEE registration area before 9:00 a.m. (Mountain Time Zone), June 26, 1994. The sponsoring divisions of the ASEE will not be responsible for transporting the project to Edmonton.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION — SPONSORING DIVISIONS — ENGINEERING DESIGN GRAPHICS, FRESHMAN PROGRAMS, DESIGN IN ENGINEERING EDUCATION

NATIONAL DESIGN GRAPHICS COMPETITION

Date: 6-30-93

Dear Colleague,

On behalf of the sponsoring divisions of the American Society for Engineering Education, I want to invite you to judge the National Design Graphics Competition. This event will be held in conjunction with the 1994 ASEE Convention, June 26-29, 1994, at Edmonton, Alberta, Canada.

We will start on Sunday June 26, at 9:00 a.m. and finish with lunch about noon. We will first cover the judging criteria and then the judging sheets and projects will be assigned. When you complete the judging, you will hand your score sheets for tabulation. The scores will be compiled and the results will be announced at the at the sponsoring division banquets.

If you will be in attendance and would like to help judge, please fill in the enclosed Judging Interest form and mail to the printed address.

Sincerely,

Patrick J. McCuistion

- CUT ALONG THIS LINE -

JUDGING INTEREST FORM
1994 ASEE NATIONAL DESIGN GRAPHICS COMPETITION
Edmonton, Alberta, Canada

I am interested in judging the 1994 competition. Please contact me in February 1994 to confirm my availability. Please use single stroke gothic capitals.

Name: ____________________

Address: ____________________

____

____

Phone #: ____________________

FAX #: ____________________

Please mail to: Patrick J. McCuistion, 120 Stocker Center, Ohio University, Athens, OH 45701-2979

AMERICAN SOCIETY FOR ENGINEERING EDUCATION — SPONSORING DIVISIONS — ENGINEERING DESIGN GRAPHICS, FRESHMAN PROGRAMS, DESIGN IN ENGINEERING EDUCATION

1994 ASEE NATIONAL DESIGN GRAPHICS COMPETITION
PROJECT INTEREST FORM
Edmonton, Alberta, Canada

Our institution is considering submission of student design projects:

Number of Freshman projects ____ (3 permitted)

Contact person at your institution:

Full Name: ______________________________

Address: ______________________________

____

Phone #: ____________________ Fax #: ____________________

Please mail to:

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

<u>This form due by February 1, 1994</u>

- - - - - - - - - - CUT ALONG THIS LINE - - - - - - - - - -

1994 ASEE NATIONAL DESIGN GRAPHICS COMPETITION
REGISTRATION FORM
Edmonton, Alberta, Canada

All the information on this form should be the same as you wish it to appear on any award.

School: ______________________________

Advisor(s): ______________________________

Address: ______________________________

____

Phone #: ____________________ Fax #: ____________________

Team Members: ____________________ ____________________
(limit of four) ____________________ ____________________

Please mail to:

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

<u>This form due by April 1, 1994</u>

2nd ANNUAL Irwin/CADKEY Drawing Contest Winners
EDGD Mid-Year Meeting •San Francisco •January 1993

There were 36 entries in the 2nd Annual contest which, unfortunately, was fewer than last year. These entries were from graphics students at a variety of schools. The following schools were represented: York Technical College, County College of Morris, Evergreen Valley College, Ferris State University, Cogswell College-North, Southern College of Technology, Florida Institute of Technology, Okaloosa-Walton Community College, Clemson University, East Carolina University, LeTourneau University, Montana State University, Old Dominion University, Penn State-McKeesport, John Tyler Community College, Purdue University, University of Texas at Austin, as well as three entries from Simeon Vocational High School.

The judges for this contest were Terry Burton of Purdue University, Tom Sweeney of Hutchinson Technical College and Doug Frampton of the University of Akron.

The drawings with the highest point total in each category were chosen as best of category winners, and the best of show winner was the drawing with the highest point total overall.

The categories for drawings were as follows:

1. Freehand Technical Illustration
2. Mechanical Drafting
3. Technical Computer Illustration
4. Computer-aided Design

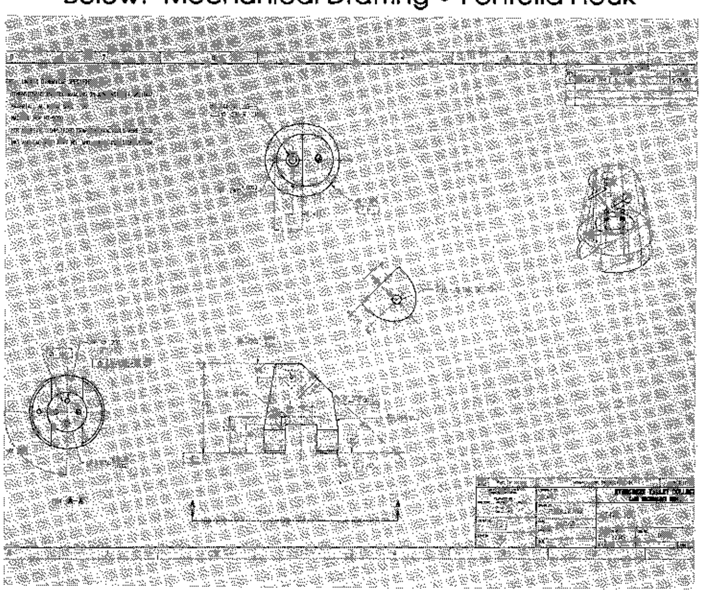
Freehand technical illustration and CAD were the most competitive categories.

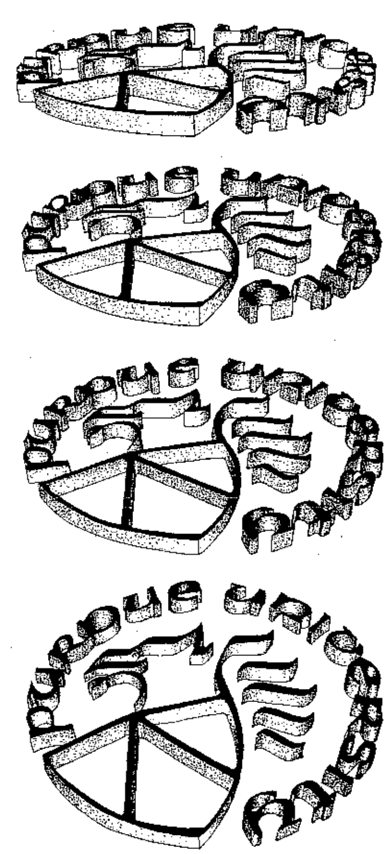
Winning students received their choice of CADKEY 5.0 or DataCAD 4.0. The schools received a parallel software award.

The announcements for the third annual contest have already been sent to instructors of two- and four-year schools A new category, Solids Modeling, has been added to the contest. Once again, the drawings will be on display at the ASEE's Engineering Design Graphics Division Meeting in November in Athens, Ohio. If you wish to be added to our mailing list for the drawing contest, please contact by mail:

Christine Bara, Editorial Coordinator,
Richard D. Irwin Publishing,
20 Park Plaza, Suite 320,
Boston, MA 02116,
or by phone (800) 522-2661 or (617) 451-1090;
Fax (617)451-2437.

Below: Mechanical Drafting • Fontella Houk

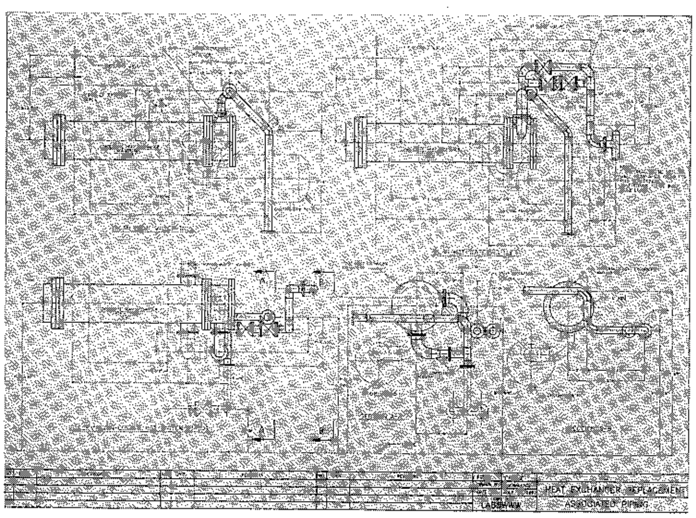




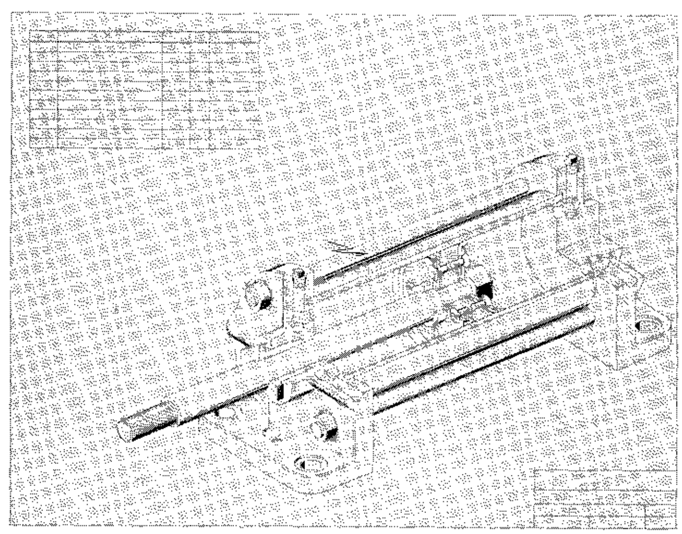
Best of Show & Freehand Technical Illustration • Mark Slivovsky

2nd Annual Contest Winners

Category	Student	Instructor
Freehand Technical Illustration & Best of Show	Mark Slivovsky Purdue University	Mary Sadowski Purdue University Dept. of Technical Graphics
Mechanical Drafting	Fontella Houk Evergreen Valley College	Loren Fromm Evergreen Valley College CAD Department
CAD	Willie W. Wallace John Tyler Community College	William Wyatt John Tyler Community College
Technical Computer Illustration	Russell Watford Southern College of Technology	James Stephens Southern College of Technology
Honorable Mentions	Willie W. Wallace John Tyler Community College	William Wyatt John Tyler Community College
	Russell Watford Southern College of Technology	James Stephens Southern College of Technology
	Monica Hei University of Texas at Austin	Billy H. Wood University of Texas at Austin
	Tim Kritikos Penn State-McKeesport	Merwin L. Weed Penn State-McKeesport



CAD • Willie W. Wallace



Technical Computer Illustration • Russell Watford

Deadline for entries this year is October 1, 1993.

Centennial Medallion

1993 marks 100 years of progress and accomplishments, of dedicated service, and of striving to improve what, in 1893, was an education fraternity serving practitioners still 26 years from recognition as a licensed profession.

The centennial marks the beginning of ASEE's second century of dedication to furthering engineering education and serving the engineering profession and the nation.

To celebrate this milestone, 170 male and 5 female eminent engineers have been selected to receive special Centennial Medallions. These medallions recognize living individuals who have had a significant and lasting impact on engineering education or engineering technology education and whose professional activities affirm ASEE values. The distinguished members of this small group are notable for their extraordinary contributions in these areas.

The medallion for this occasion was designed by Paul DeJong of Iowa State, a long-time, active member of EDG. The design of the medallion illustrates the past, present, and future of ASEE.

Six current EDGD members received the Centennial Medallion.

- **George C. Beakley**
  Arizona State University
- **Paul DeJong**
  Iowa State University
- **James H. Earle**
  Texas A & M University
- **Arvid R. Eide**
  Iowa State University
- **Willard E. Nudd**
  Case Western Reserve University
- **Ernest E. Weidhaas**
  Pennsylvania State University

Centennial Certificate

As part of the American Society for Engineering Education's 1993 Centennial Celebration, the various ASEE units are awarding Centennial Certificates of Recognition to individuals and organizations that have provided exemplary support for ASEE.

Since ASEE was formed in 1893 at the World's Engineering Congress in Chicago, engineering education has changed dramatically. ASEE has played a major role in that change as the sponsor of the many studies and reports that have guided engineering education. The Society has established itself as a leader in promoting excellence in engineering and engineering technology education primarily because of the commitment of its individuals and organization members. It is through this kind of support that ASEE has been able to contribute so much during this first 100 years.

CRITERIA FOR INDIVIDUAL RECOGNITION

1. All living Distinguished Service Award Recipients
2. All living Past Chairs
3. Current Chair & Vice Chair
4. All living Directors of Publication (*EDG Journal* Editors)

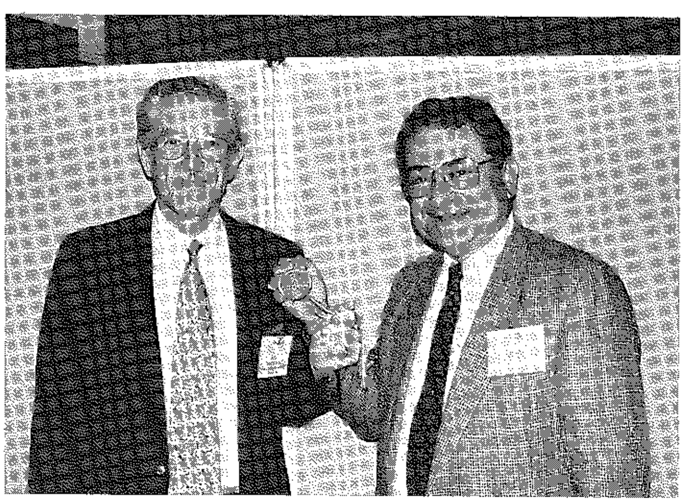
Following is a list of EDG members who received Centennial Certificates.

Individuals:

Ivan L. Hill
Edward M. Griswold
Earl O. Black
Robert H. Hammond
Mary Plumb Blade
Claude Z. Westfall
Clarence E. Hall
Frank Oppenheimer
Warren J. Luzadder
Steven M. Slaby
James H. Earle
Percy H. Hill
William B. Rogers
Robert D. LaRue
C. Gordon Sanders
Amogene F. Devaney
Paul S. Dejong
Klaus E. Kroner
Clyde H. Kearns
Robert J. Foster
Larry D. Goss
Jack C. Brown
Arvid R. Eide
Garland K. Hilliard
Roland D. Jenison
Ronald E. Barr
Mervin L. Weed
Frank M. Croft
Jon K. Jenson
John T. Demel
Vera B. Anand
J. Barry Crittenden
Jon M. Duff
Mary J. Jasper
Mary A. Sadowski
Albert Romeo
Borah L. Kerimer

Companies:

William C. Brown & Co.
Autodesk, Inc.
Cadkey, Inc.
Richard D. Irwin, Inc.



Arvid R. Eide & Paul S. DeJong,
Recipients of the ASEE Centennial Medallion.

The *Engineering Design Graphics Journal* is published three times a year by the Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE).

Subscription rates: ASEE/EDGD members , $6.00; non-members, $20.00; ASEE institutions, $10.00.

If you would like to become a member of EDGD/ASEE, write ASEE, Suite 200, 11 Dupont Circle, Washington, D. C. 20036, and request an ASEE membership application.

Non-members can subscribe to the *EDG Journal* by sending their name, address, telephone number, and a $20.00 check or money order payable to Engineering Design Graphics

Mail to:

Clyde Kearns
The Ohio State University
2070 Neil Avenue
Columbus, OH 43210

Submission of Papers and Articles for the *Engineering Design Graphics Journal*

The *Engineering Design Graphics Journal* is published by the Engineering Design Graphics (EDG) Division of the American Society for Engineering Education (ASEE). Papers submitted are reviewed by an Editorial Review Board for their contribution to Engineering Graphics, Graphics Education and appeal to the readership of the graphics educators. By submitting a manuscript, the authors agree that the copyright for their article is transferred to the publisher if and when their article is accepted for publication. The author retains rights to the fair use of the paper, such as in teaching and other nonprofit uses. Membership in EDGD-ASEE does not influence acceptance of papers.

Submission

Material submitted should not have been published elsewhere and not be under consideration by another publication.

Submit papers, including an abstract as well as figures, tables, etc., in quadruplicate (original plus three copies) with a cover letter to:

Mary A. Sadowski, Editor
Engineering Design Graphics Journal
1419 Knoy Hall / Technical Graphics
Purdue University
West Lafayette, IN 47907-1419

Cover letter should include your complete mailing address, phone and fax numbers. A complete address should be provided for each co-author.

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. All line work must be black and sharply drawn and all text must be large enough to be legible if reduced to single or double column size. The editorial staff may edit manuscripts for publication after return from the Board of Review.

Upon acceptance, the author or authors will be asked to review comments, make necessary changes and submit both a paper copy and a text file on a 3.5" disk.

Page Charges

A page charge will apply for all papers printed in the *EDG Journal*. The rate is determined by the status of the first author listed on the paper at the time the paper is received by the Editor. The rates are as follows:

$5 per page for EDGD members
$10 per page for ASEE members who are not members of EDGD
$50 per 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:

Mary A. Sadowski
Editor, EDGD Journal
Technical Graphics/Knoy Hall
Purdue University
West Lafayette, IN 47907-1419

FAX: 317-494-0486
PH: 317-494-8206

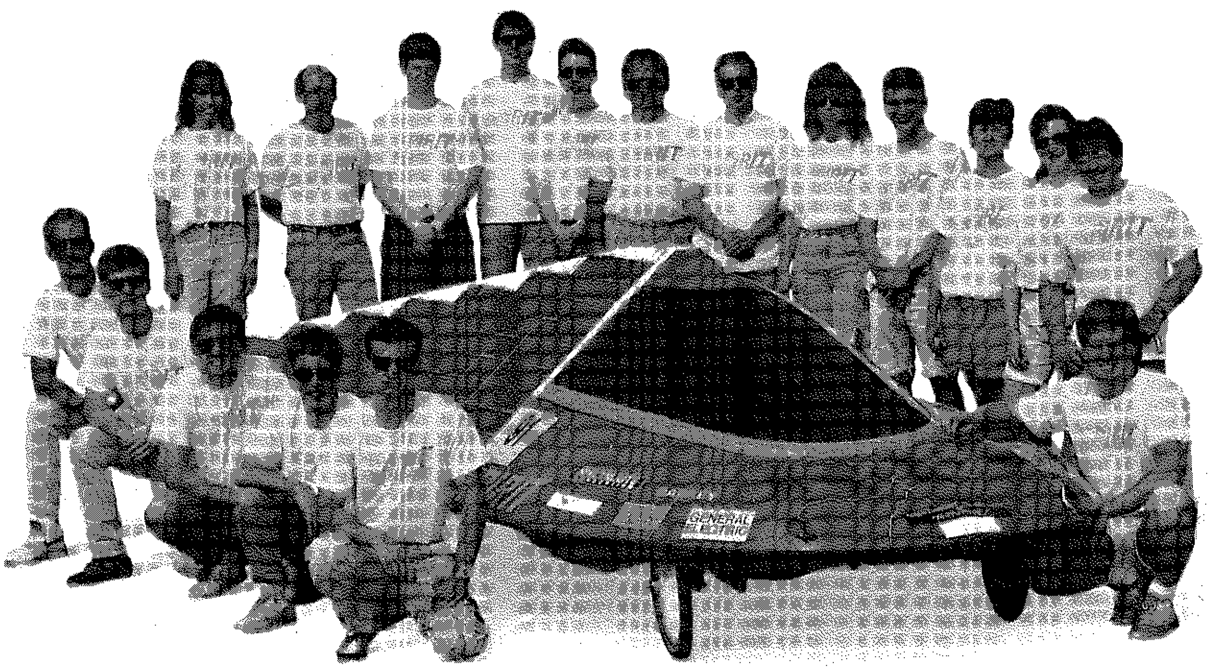
The EDG Journal is entered into the ERIC (Educational Resources Information Center), Science, Mathematics, and Environmental Education/SE at:

The Ohio State University
1200 Chambers Road, 3rd Floor
Columbus, OH 43212.

Article copies and 16, 35, and 105 mm microfiche are available from:

University Microfilm, Inc.
300 Zeeb Road
Ann Arbor, MI 48106

In the race to invent the future, this RIT team chose CADKEY.®



When Rochester Institute of Technology engineering students decided to enter a GM-sponsored solar powered competition they only had two problems: No car, and very little time to build one.

But when SPIRIT, a 435 pound powerhouse, rolled onto the track for the first time, skeptics asked: "How?" The answer: CADKEY.

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