Hypergraphics

Visualizing Complex Relationships in Art, Science and Technology

Edited by David W. Brisson

AAAS Selected Symposium 24

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About the Book

Visualization in its many forms has been a major contributing factor in the historical development of scientific thought. Yet in recent years there has been an increasing tendency to exclude visualization from the process of scientific exploration, and a similar tendency to exclude abstract mathematical formulations from the arts. These dissociations are destructive to a full, rich comprehension of either the arts or the sciences. To counter this trend, hypergraphics – a new field comprising computer graphics, perceptual psychology, and modern geometry – endeavors to develop new aids to understanding and communicating complex, multidimensional relationships.

Hypergraphics blends contemporary thinking in art and science by developing methods whereby our ability to visualize may be brought into active cooperation with our ability to reason abstractly, thus integrating these two modes of human thought and consciousness. This volume reviews developments in hypergraphics from the perspectives of a variety of fields in art and science.

About the Series

The *AAAS Selected Symposia Series* was begun in 1977 to provide a means for more permanently recording and more widely disseminating some of the valuable material which is discussed at the AAAS Annual National Meetings. The volumes in this *Series* are based on symposia held at the Meetings which address topics of current and continuing significance, both within and among the sciences, and in the areas in which science and technology impact on public policy. The *Series* format is designed to provide for rapid dissemination of information, so the papers are not typeset but are reproduced directly from the camera-copy submitted by the authors, without copy editing. The papers are organized and edited by the symposium arrangers who then become the editors of the various volumes. Most papers published in this *Series* are original contributions which have not been previously published, although in some cases additional papers from other sources have been added by an editor to provide a more comprehensive view of a particular topic. Symposia may be reports of new research or reviews of established work, particularly work of an interdisciplinary nature, since the AAAS Annual Meetings typically embrace the full range of the sciences and their societal implications.

WILLIAM D. CAREY
Executive Officer
American Association for
the Advancement of Science

About the Editor and Authors

David W. Brisson, associate professor of design at the Rhode Island School of Design, is a painter and sculptor, and for the past 15 years has been working in the area of geometry and perception. He invented the three-dimensional anaglyph and the hyperstereopticon and devised a method of making three-dimensional lenticullar drawings, hyperstereograms, and other forms. His art has been exhibited throughout the United States, and he has organized a number of symposia and exhibitions on hypergraphics. Among his books are Curved 4-Space *(1976), and* A New Reality: A Theory of Dimensionality *(1976).*

Thomas F. Banchoff, professor of mathematics at Brown University, specializes in the geometry and topology of differential and polyhedral manifolds. He has received Woodrow Wilson and Danforth Fellowships and a Fulbright Travel Award and is a member of several professional societies. His numerous articles concern the geometry of curves and surfaces, polygons and polyhedra in 3- and 4-dimensional space, and computer graphics in geometric research.

Harriet E. Brisson, a sculptor and ceramicist at Rhode Island College, has shown her work in hypergraphics at various exhibitions, and her honors include first prize for sculpture at the Fall River Art Association National Exhibit and first prize from the Newport Art Association. She is also active in the American Crafts Council and was the U.S. delegate to the World Craft Council Conference in 1978.

Scott E. Kim, a computer programmer at Logicon, Inc., in San Pedro, California, holds a B.A. in music from Stanford University, where he worked at the Computer Center for Research in Music and Acoustics. He is interested in the contribution of computer graphics to mathematical and artistic visualization, particularly transformations in time. He is a member of SIGGRAPH, has written articles on mathematics and

music, three- and four-dimensional dissections, and invertible calligraphy, and has contributed articles on tilings and tesseracts to the Scientific American *mathematical games column.*

C. Ernesto S. Lindgren, professor in the Department of Urban and Regional Planning at the Federal University of Rio de Janeiro, specializes in quantitative methods in urban and regional planning. He is the author of Four-Dimensional Descriptive Geometry *(with Steve M. Slaby; McGraw-Hill, 1968) and* Developments in Four-Dimensional Descriptive Geometry *(Brazil: COPPE/UFRJ, 1977) and is a recipient of the "Descriptive Geometry Award" from A.S.E.E.*

Arthur L. Loeb, senior lecturer in the Department of Visual and Environmental Studies at Harvard University, specializes in design science. He has published numerous articles on a broad range of subjects, including physics, structure and patterns, computers and programmed instruction, crystal algebra, and symmetry theory, and is the author of Color and Symmetry *(Wiley, 1971) and* Space Structures, Their Harmony and Counterpoint *(Addison-Wesley, 1976). His work has been exhibited at Harvard, Smith College, Rhode Island School of Design, and other locations, and he has been elected to numerous professional societies.*

A. Michael Noll, marketing supervisor at American Telephone and Telegraph Company, has worked extensively in computer graphics, man-machine communications, and speech processing. His computer art has been exhibited throughout the world and he has created several computer movies. A member of the editorial advisory board of Computers and Graphics, *he has published over 35 papers and been granted 5 patents in his fields of interest.*

Steve M. Slaby, associate professor in the Department of Civil Engineering at Princeton University, works primarily in descriptive geometry and the impact of technology on society. He has received awards from Tau Beta Pi and the Lawrence Institute of Technology. His publications include Fundamentals of Three-Dimensional Descriptive Geometry *(Harcourt, Brace & World, 1966) and* Four-Dimensional Descriptive Geometry *(with C.E. Lindgren; McGraw-Hill, 1968).*

Cyril Stanley Smith is Institute Professor Emeritus at the Massachusetts Institute of Technology. His areas of specialization are metallurgy and the history of technology, and he was director of the Institute for the Study of Metals at the University of Chicago for 15 years. He is the author of A History of Metallography *(University of Chicago Press,*

1960). He has been awarded honorary degrees from Case-Western University and the University of Pennsylvania.

Charles M. Strauss is a research associate in the Department of Mathematics at Brown University. He has worked on the use of computer graphics in geometric research and has developed methods for producing computer-generated films.

Anne Griswold Tyng is an independent architect and a lecturer at the Department of Architecture, Graduate School of Fine Arts, University of Pennsylvania. Her work is focused on geometric ordering principles at all levels of form, and she has published articles and video films on this topic and in related areas. She has lectured and exhibited her work worldwide, and she is a fellow of the American Institute of Architects and an associate member of the National Academy of Design.

J. M. Yturralde, an internationally known painter from Valencia, Spain, works also with computer-generated art forms, and has held several exhibitions and lectured on this subject in Europe. A Scholar of the Direccion General de Bellas Artes and of the Computer Center of the University of Madrid, he was awarded first prize in the International Ibizagrafic 72 Exhibition, as well as the international B.J. Salvi prize, and the Premio Europa Ancona Italy. He was a fellow at the Center for Advanced Visual Studies at MIT in 1975.

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Contents

Introduction

David W. Brisson

"Hypergraphics" may be described as graphics that transcend traditional means. In a very specific sense it refers to n-dimensional descriptive geometry. In a broader sense it refers to any transcendent visual concern. It is in this broader sense that this collection of essays has been assembled.

The authors of these essays have been interacting with each other for a number of years at symposia and exhibitions and through the personal exchange of work and ideas. Since the authors represent a broad spectrum of disciplines in the arts and sciences, a superficial perusal of the titles of these papers does not immediately give the reader a clear sense of the fundamental core that binds them together. Upon examining the material more closely it will be found that these ties consist of a preoccupation with the visual, and basically geometrical, transformation of information; the novel character, beauty and complexity of such transformations; the concern with the promise of new methods for dealing with the many problems of the day; and finally, the adventure of exploration.

Steve Slaby's work represents the most direct concern with technical aspects of transcendent descriptive geometry. He has been involved with the translation of an early German text on the subject of four-dimensional geometry, an original text on the subject in collaboration with C. Ernesto Lindgren, as well as other works. Steve's paper serves to supply perspective on the subject.

C. Ernesto Lindgren has been involved with the application of such concepts to city planning and architecture for many years. Ernesto and I had long conversations about this potential of n-dimensional geometry ten years ago when he was working with computor graphics at Harvard University. Since

that time he has continued, in Brazil, to develop such methods of application in conjunction with practical problems in urban planning.

Arthur Loeb is a scientist who has long been interested in the teaching of design. Through geometrical reasoning, he attempts in his chapter to formulate a more rigorous approach to the process of "visual" design, a "design science." His teaching involves the extensive use of mathematical models, and his encouragement of his students has produced superlative results in the exploration of design by means of its geometrical aspects. His work in this area extends beyond the classroom in his active and vigorous support of an interdisciplinary group of scholars called the Philomorphs, who are interested in visual aspects of form and who meet once a month on the Harvard campus.

Several years ago, Arthur asked me to give a presentation on four-dimensional geometry to the Philomorphs. The presentation evoked sufficient interest to generate an exhibition, "Virtual Realities," organized by Toshihiro Katayama and held at the Carpenter Center for the Visual Arts at Harvard in 1976. The participants in that exhibition included myself, Harriet Brisson, who was engaged at the time in building tensegrity models of close-packing polyhedra, and Jose Yturralde, the Spanish painter and graphic artist, who was at that time a fellow at the Center for Advanced Visual Studies at M.I.T. Jose's work consisted of silk-screen prints of "impossible" geometrical figures (illustrated in his paper in this volume).

Jose's paper is concerned with his attitude of exploration into a transcendant visual world and his philosophical approach to his art. His work extends to three-demensional models, and he has developed beautiful kites as an extension of that work. (In a desire to participate more fully in this work he practiced hang-gliding!) His home in Valencia is not too far from Granada, site of the Alhambra, the great source of geometrical art for many European artists, including Escher to whom Jose owes much inspiration.

Harriet Brisson's paper, like Jose's, is in effect a statement of personal philosophical objectives, an outline of the concerns of her work. It is in her neon sculptures that Harriet's work truly begins to transcend ordinary sculptural form. Unfortunately, the photographs of her work do not adequately give the visual "magic" of the semi-mirrored images with their infinite extension and their glowing color.

My work in the "Virtual Realities" exhibition consisted of a variety of four-dimensional models in various media, and some hyperanaglyphs of several four-dimensional forms. The hyperanaglyph is an analog extension of the red and blue "glasses" used in 3-D comic books years ago. In this case a four-dimensional polytope is projected from four dimensions to three, constructed out of welded rods and painted red. The polytope is then rotated about six degrees in four dimensions around a plane, projected to three dimensions, constructed and painted blue. This compound structure is then rotated in three dimensions while being viewed with the red and blue glasses. The effects are rather startling and unlike any ordinary experience of three dimensions.

At the "Virtual Realities" exhibition Tom Banchoff and Charles Strauss of Brown University showed their films of rotating hyperfigures. The effects of these films are very similar to the effects of the hyperanaglyphs. They are remarkably beautiful and the reproductions in this volume, which are selected frames from their films, again do not do justice to their beautiful color and the incredible effects of the animation.

Tom and Charles have been actively engaged in trying to mesh the efforts of art students and mathematics students from the two schools by offering joint courses and encouraging interdisciplinary study. Tom and Charles form a close to perfect symbiosis, Tom supplying the geometrical theory and Charles the computer technology. Together, after long and laborious experimentation with hardware and software techniques, they have arrived at methods for producing computer-generated films that would appear to rival any computer-generated films produced anywhere, both in form and content.

These films are of course related directly to the pioneer work of A. Michael Noll whose 1967 essay is reprinted in this volume. Michael has been interested in computer graphics and transcendant images for a long time and has lectured widely on this subject. Michael's paper is one of several that he has written on computer graphics. One of his concerns, shared by Banchoff and me, has been to discover some means of perceiving, either directly or indirectly, a four-dimensional figure. His interest in this specific problem is but one of a wide range of computer-based concerns, which include his computer simulation of the neo-plastic work of the painter Piet Mondrian. He has been concerned with computer graphics as an art form in itself, and he has experimented with computer-generated tactile visualization, what Huxley would have called "feelies."

As a result of the Carpenter Center exhibition I was encouraged to organize an exhibition and symposium, "Hypergraphics," in 1977 at the Rhode Island School of Design. About forty scientists and artists participated in the exhibition and discussions. Among them were Arthur Loeb and Cyril S. Smith, who in his long, distinguished career as a scientist has maintained a deep commitment to art and its relation to science. Concurrent with the symposium, Cyril Smith developed an exhibition at the Smithsonian concerned with the technology of many art objects in history. His background as a metallurgist has given him a profound respect for geometry as one of the bases of organized thought, and Arthur Loeb's background in crystallography has similarly affected him. Cyril's work is careful and scholarly, and concerned with the unification of work in the arts and sciences. His concern revolves around the profound connection between visual and verbal thought in art and science which is the root of this whole study.

At this symposium Banchoff's and Strauss' films were again shown, this time to an enthusiastic audience of more than 200 art students. I showed my hyperanaglyphs and a somewhat crude version of a kinetic hyperstereopticon. Toshihiro Katayama exhibited a number of silk-screen prints of "impossible" figures and a number of other artists and scientists exhibited work. Another scientist who met with the group at that time was Gregg Edwards of the National Science Foundation who presented films produced over the last several years that were related to our concerns, and he discussed the interconnections between the various disciplines and the future implications of activities related to hypergraphics. He brought to the group a particularly wide range of interests and the desire to formulate significant generalizations.

Among the exhibitors was Denis Finch, a scientist turned sculptor, who exhibited kinetic shadowgraph sculptures of rotating hyperfigures. Beautifully crafted, they formed a connecting link between the films of Banchoff and Strauss and my hyperanaglyphs. Harriet Brisson exhibited new tensegrity close-packing structures, and Arthur Loeb exhibited models of the dissection of the cube. There were of course many others who exhibited work and participated in the discussions and who are still actively involved in the production of transcendant images. "Hypergraphics" was through their efforts and interplay quite a successful affair in many ways.

Following this exhibition and symposium, Gregg Edwards urged me to arrange a similar exhibition and symposium at the annual conference of the American Association for the Ad-