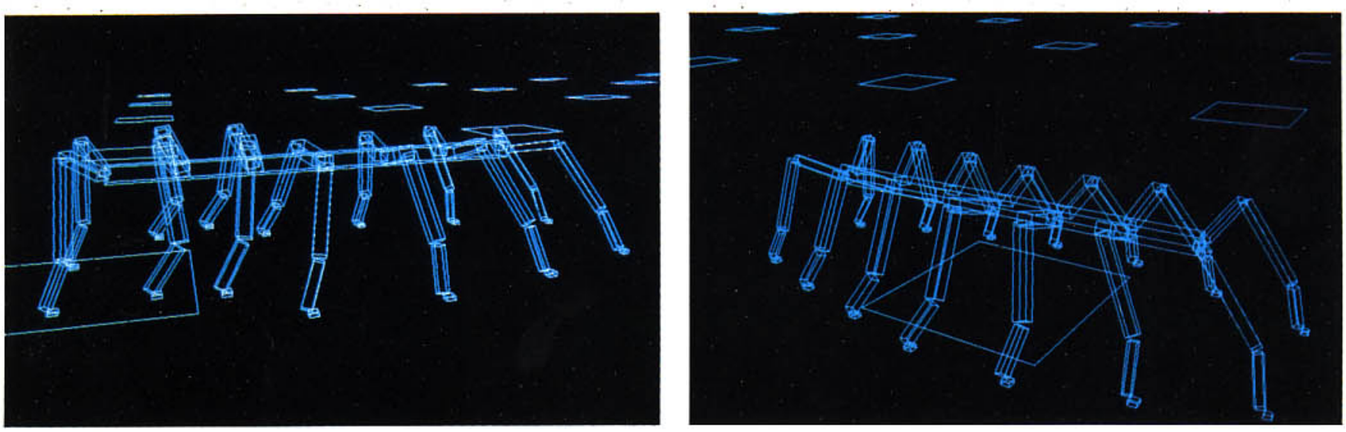
# Ohio State Pioneers Computer Animation

## Making Birds Fly and Babies Walk

By Thomas E. Linehan, Ohio State University

**Figure 1: The display of complex scenes, as in this ray-traced image by David Lister, is one of the Computer Graphics Research Group's primary research initiatives.**



Blending science and aesthetics in computer animation is a 20-year tradition at Ohio State University. Inspired by Charles Csuri, the Computer Graphics Research Group goes beyond the problems of mere movement and searches for ways to bring computer images to life.

Located in the College of Arts, the CGRG is an interdisciplinary unit with members from The Department of Electrical Engineering and the Department of Art Education. The National Science Foundation, the Department of Navy and the university provide funding.

**Research Activities**

Two research initiatives characterize (CGRG's) current activities: (1) the display of complex scenes, as represented by David Lister's ray traced image (Figure 1) and the naval shipyard by Paul MacDougal (Figure 2); and (2) motion control of complex articulated figures, as represented by Michael Girard's running figure (Figure 3). Beginning efforts are underway involving facial animation development, the incorporation of artificial intelligence strategies for animation, and the retrieval of nuclear magnetic resonance data for animation.

There is considerable interest in the development of procedural techniques for the generation of data points with which to construct objects. Standard techniques such as solids of revolution, projection and lofting are used often. Programs are also written to generate spiral and gear-like structures (Figure 4), allowing the user to specify certain characteristics of the objects.

The film "Hidden Agenda" is a case example of special-purpose programs written for the control of certain animation sequences (Figure 5). The animation depicts a series of transformations through which a set of unordered elements are organized into increasingly complex, structural schemes, finally emerging as a unified whole. The transformations are performed continuously and effortlessly, as if the elements were motivated by some "hidden agenda." The motion is controlled by special purpose programs in which objects are warped to mathematically defined, free-form curves and surfaces. The dynamics of motion and shape interpolation use periodic repetition based on polyrhythmic relationships.

**Figure 2: Paul MacDougal's naval shipyard (below) is another example of a complex-scene rendering. Figure 3: Michael Girard's running figure (above) illustrates the CGRG's advances in motion control.**

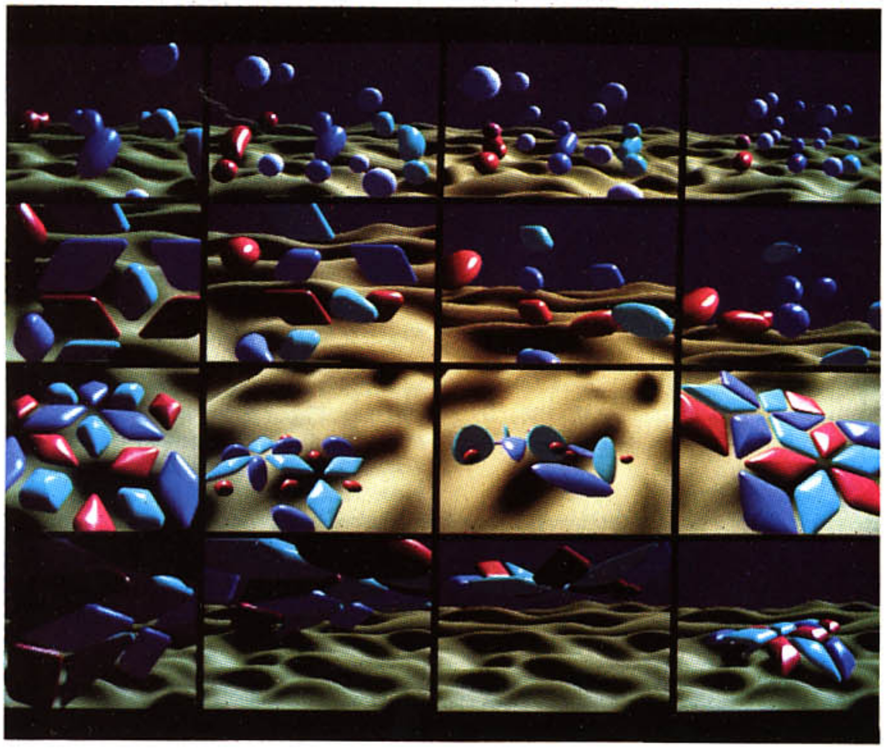


**Figure 4 (top): "Spirals," by Doug Kingsbury, was created with a program designed to generate gear-like structures. Figure 5 (bottom): These frames from "Hidden Agenda," by Susan Amkraut and Michael Girard, were generated with a special-purpose animation program.**

The animation study "Fruit Flavors" will use similar programs for motion control (Figure 6). The film uses a circular configuration of squares scaled from the same origin by increments which reflect the Fibonacci series. The 16 frames that compose the image are instances of movement toward the center of the boxes.

VanBaerle and Kingsbury needed more than one special purpose, motion control program to animate "Snoot and Muttly," in which their bird-like characters strut about a tropical environment. The emphasis in the film is on story telling through expressive gestures and motion. The characters have jointed legs, flexible tails and necks, and moving eyes and mouths. Maintaining the birds' proper frontal orientation as they moved about required considerable attention. The contrasting personalities of the two birds are defined by characteristic gaits; Snoot maintains a proper, strut-like motion through most of the film while Muttly moves in an exuberant, unreserved and unstudied gait. Both general and special purpose programs are used throughout the film.

"Snoot and Muttly" demonstrates the critical need for general purpose programs that enable the animator to control motion dynamics. Character animation will never be practical as long as the subtle variation in motion requires a special case implementation because expressive motion is the heart of character development. Several solutions to this problem are currently used or under development by the CGRG.

### Automated "Tweening"

The system used to animate Snoot and Muttly, TWIXT, was developed by Julian Gomez. It is a visually interactive, 3D, computer animation system that can perform automated "tweening" (filling in steps between extreme points of movement) of tracks defining an animation sequence. Lists of events stored in tracts control animation. Tracks are interpolated by functions that have an arbitrary

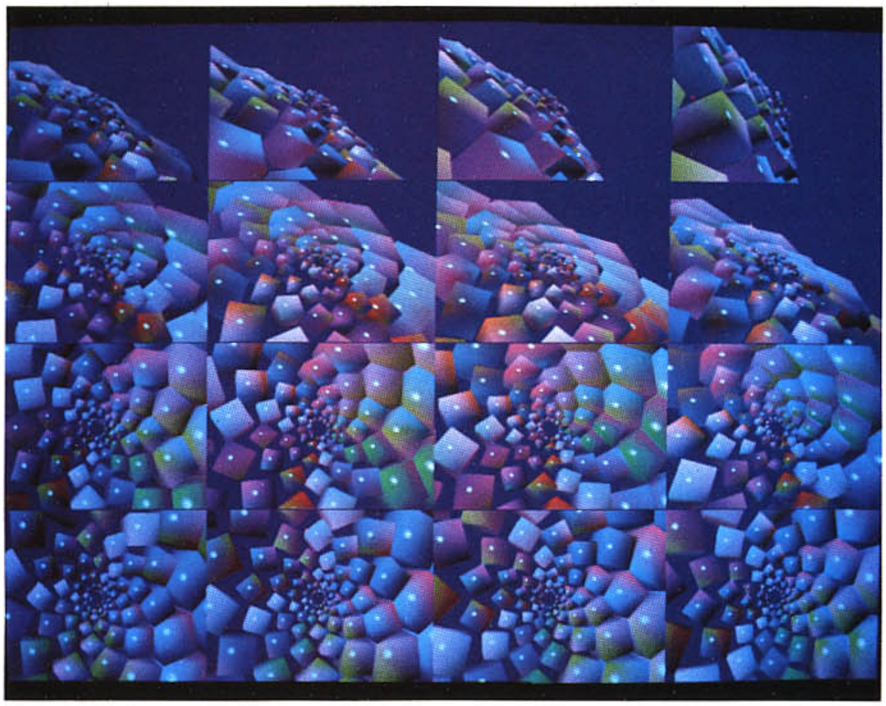


**Figure 6 (top): The circular configuration of squares in "Fruit Flavors," by Bill Woodward, is scaled in increments reflecting the Fibonacci series. Figure 7 (bottom): "Snoot and Muttly," by Susan VanBaerle and Doug Kingsbury, uses several animation programs.**

degree of knowledge about how to control display parameters. The system provides real-time, wire-frame play-back for the animator's inspection. It is both input and output device independent.

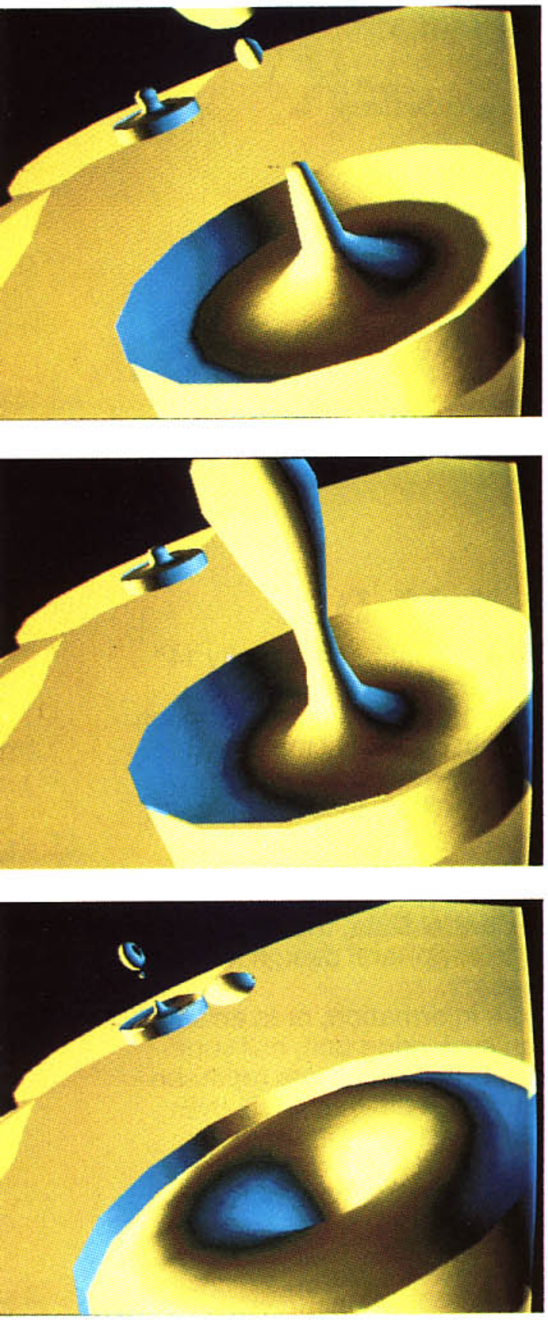
TWIXT was also used in John Donkin's film, "Trash" (Figure 8). Here, a small trashcan hops about a city street in an effort to find a peaceful night's sleep. The trash-can undergoes a substantial number of 3D shape transformations as it hops around and suffers the abuse heaped upon such a lowly urban dweller.

"Tuber's Two-Step" is a short tale about a family baby taking its first steps (Figure 9). The film is reminiscent of the old classic cartoons set to swing music. The characters are heavily stylized and possess the happy, bouncy quality of motion known in early cartoons. Joints and certain limb parts are removed in the interest of economy and style. The animation of the remaining body parts relies on visual closure to construct what appears to be a whole creature. (The closure effect is more difficult to achieve in the stills presented from the film. The parts form a whole more readily when viewed in motion.) The tuber-like characters incorporate the time-honored animation techniques of stretching and squash, emphasizing their bounce and fluidity.

### Legged Motion

The animation of creatures with legs has been extremely difficult in 3D computer animation. The complex kinematic and dynamic relationshps must be maintained to synthesize realistic legged motion. Conventional animation systems, which rely on joint angle interpolation, fail to address the problems of integrating the motion of dynamics of a creature's body and legs.

The Poda animation system, developed by Michael Girard, was inspired by recent advances in robotics; specifically, control algorithms for steering walking machines. Poda is a general application system designed to provide



Three frames from an animation sequence created by Ohio State's Computer Graphics Research Group.

## Educating the Computer Animator

In the highly competitive market for top-quality animation, the aesthetic sensitivity of the artist often makes the difference between a successful project and one that fails. The computer animator faces the double challenge of mastering the arcane workings of computers as well as traditional artistic techniques. Because Renaissance men and women—those who naturally combine scientific and artistic expertise—are rare, a new kind of education for computer animators seems to be in order.

The new computer animator requires an education similar to and different from the traditional artist. A foundation in traditional art media provides the basis for good graphics and animation. Knowledge of structured programming is a prerequisite to the creation of art in a computer environment. Knowledge of film, video, and traditional animation techniques must be combined with computer graphics knowledge.

Ohio State University's Department of Art Education offers a unique specialization in computer graphics in its MA degree and PhD programs and also offers undergraduate introductory courses. Students take additional course work in computer and information science, architecture, engineering graphics, photography and cinema, and educational technology. Students pursue their studies using microcomputer facilities within the department and through the facilities of The Computer Graphics Research Group.

For 10 years, the program at Ohio State has offered entrance to the high-technology field of computer graphics through the arts and education. It provides both research and instructional opportunities for faculty and students interested in aesthetic and educational applications. The commitment to this direction provides a basic philosophical orientation to the current instructional practice and has attracted national and international attention.

The Department of Art Education receives several hundred graduate study applications for the program each year, but only about 10 students are admitted. Expansion is anticipated; however, the ratio of students to faculty and equipment will be maintained at current levels to ensure quality.

### Undergraduate Curriculum

"The Arts, Education, and Computer Technology" gives a review of the history of computer graphics animation and its applications in the arts, education, and vocational training. Applications are demonstrated with videotapes.

"Microcomputer Graphics in the Arts and Education" provides a study of the production of graphics/animation on microcomputers. Students taking the course are encouraged to seek applications of micrographics in their own fields as an art form and in computer-based education.

### Graduate Curriculum

"Computer Graphics/Animation: Applications in the Arts and Education" offers a presentation of key technical, aesthetic, and educational issues related to graphics technology.

"Computer Graphics/Animation Production I" gives an introduction to animation languages and conventions of data generation. Students are required to produce a brief animation using DEC 1173 microcomputers.

"Computer Graphics/Animation Production II" continues work with animation languages and introduces scene assembler and C

Continued on page 58

programming. The course also continues work in data generation and requires the production of an animation segment using Sun workstations.

"Computer Graphics/Animation Production III" continues work with scene assembler and data generation. Students produce an extended animation segment using the VAX 11/780.

"Street Math for Artists" gives a review of college algebra from a visual or geometric perspective for applications to computer graphics and animation. It is a survey of properties of number systems, solutions to systems of equations, trigonometry, cartesian coordinates, equations of motion, functions, and analytic geometry. Matrix algebra applied to the basic transformations used in computer graphics is studied in depth.

"C Programming" introduces the C programming language.

"Digital Image Criticism" introduces a variety of critical systems derived from traditional film and photography and applied to computer imagery. Aesthetic theory relative to computer art is examined.

"Traditional Animation" reviews traditional animation techniques as a lead-in to 3D animation application studies. Traditional animation is viewed and analyzed with examples provided from Disney Studios, Warner Brothers, and the Eastern European tradition.—*TEL*

the animator with control over a computational model. This model maintains functional dependencies between the sequencing of a creature's legs, the placement of its feet, and the position and velocity of its body. The animator may design and control the behavior of creatures possessing any number of legs, composed of any number of joints (Figure 3).

The Poda system is an ongoing research project aimed at building a framework in which the synthesis of legging figure motion may be artistically conceived and controlled at increasingly higher levels of complexity and abstraction. The animation of walking and running has been demonstrated for a variety of multi-legged creatures, and work continues on motion synthesis techniques for complex motor skills, such as those used in dance and gymnastics, which exceed the requirements of naturalistic locomotion.

Simulation methods for motion control in animation sequences are also being investigated. Susan Amkraut uses such methods for control of populations through the use of vector force fields. In one particular film, a flock of birds is controlled with the vector fields assuming the form of orbits, spirals, attractors and rejectors. Collision detection is also used in this system—each bird knows about every other bird in terms of a given rejective force field. Calculations for new motion paths are based on the relative position of the other birds and the degree of attraction or rejection associated with them. While this system is still under development and is being tested in relation to control of populations, it appears to hold promise as a general system for certain classes of motion control.

### Character Animation

Considerable work remains to solve the problems of 3D character animation. The complex, articulated figure moving through space is problematic in and of itself. Gaining expressive control over that motion remains difficult. Gross control methods are more readily invented, but systems which allow for both complexity, subtle variation and ease of revision are more illusive. The implementation of limited artificial intelligence strategies in animation systems may hold promise in future development.

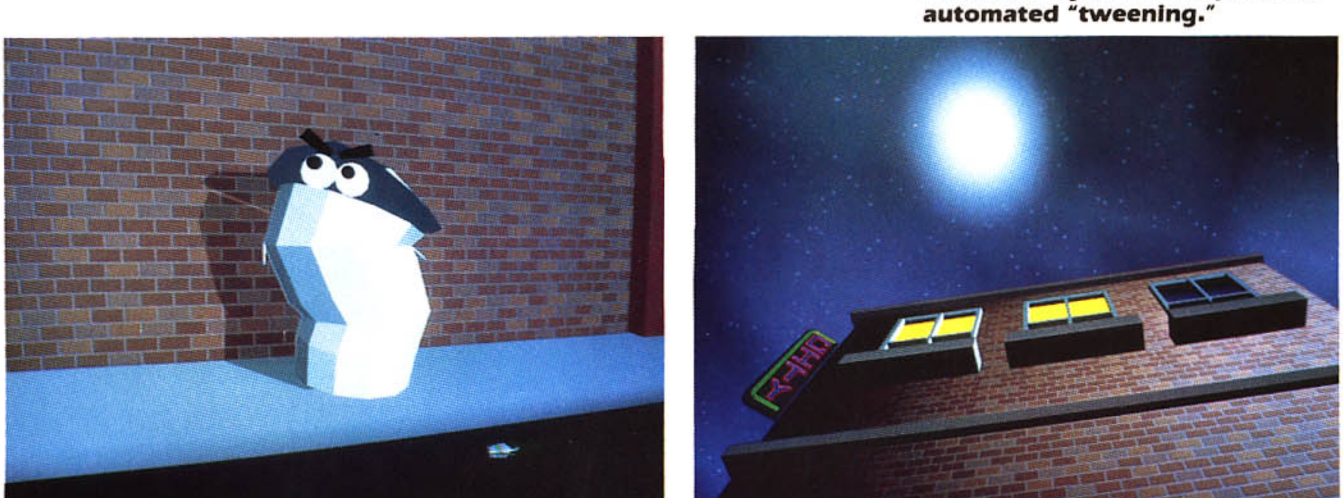


**Figure 8: Two frames from John Donkin's "Trash," which was created with TWIXT, an interactive animation system that performs automated "tweening."**

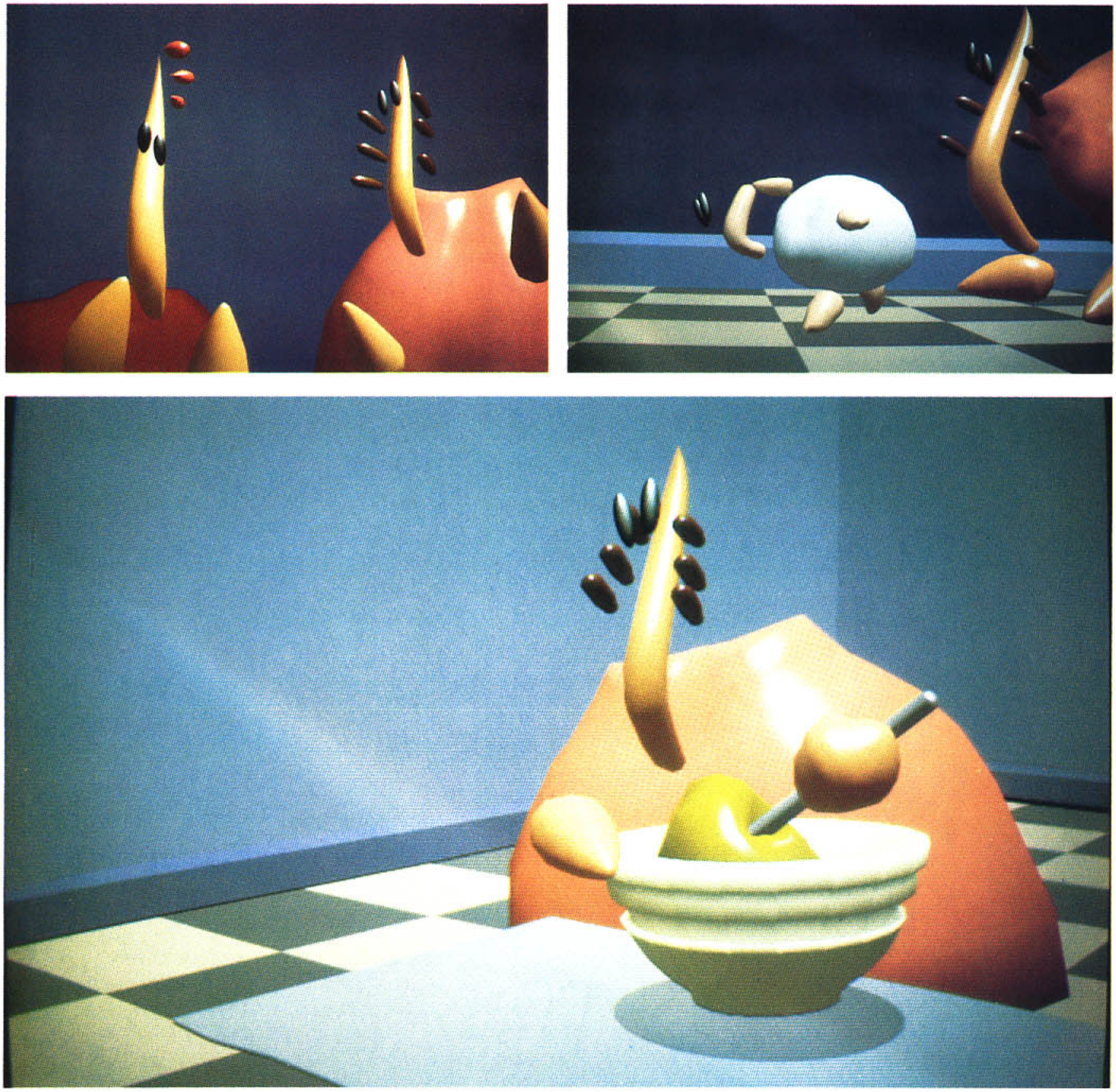


**Figure 9: These three frames from "Tuber's Two-Step" cannot do justice to the closure effect achieved in the animation.**

## Suggested Reading


Girard, M. and A. Maciejewski, "Computational Modeling for the Computer Animation of Legged Figures," *Computer Graphics, ACM SIGGRAPH '85 Conference Proceedings, Vol. 19, No. 3, July 1985.*

Gomez, J., "Twixt: A 3D Animation System," Eurographics '84 Proceedings, K. Bo and H. A. Tucker, Eds. Elsevier Science Publishers, B. V. North Holland, 1984.

Gomez, J., "Computer Display of Time Variant Functions," Ph.D. Dissertation, Ohio State University, 1985.

Kingsbury, D. "Three Dimentional, Computer-Generated Character Animation System Design," M. A. thesis, Ohio State University, 1985.

MacDougal, P., "Generation and Management of Object Description Hierarchies for the Simplification of Image Generation," Ph.D. dissertation, Ohio State University, 1984.

Schweepe, M., "Timing and Movement in 3D Computer Animation," M. A. thesis, Ohio State University, 1984.

VanBaerle, S., "Computer-Generated, 3D Character Animation," M. A. thesis, Ohio State University, 1985.