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COMPUTER ANIMATION AT UCSD

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Abstract

At UCSD's Quantitative Morphology Lab, Unix is used for the control of high performance computer graphics hardware interfaced to a film animation bench. Our animation system has been used to produce scientific films in the areas of neurosciences and linguistics. Several artists have also been turned loose on the system with interesting results.

The presentation will include a brief description of the evolution of the hardware and software and how we took advantage of Unix to save programming effort. We'll also be showing a short film made especially for the conference.

(Note: What follows is a transcript of the narration to the videotape shown at the conference, and thus is incomplete on its own. To help compensate for this, I have included the textual examples from the videotape here.—PJM)

History of QMLab

The Quantitative Morphology Laboratory started with research performed by Dr. Robert B. Livingston in the 1960's and 70's. In 1975, an award-winning film called "The Human Brain: A Dynamic View of It's Structures and Organization" was produced. In this movie, a three-dimensional model of the human brain was constructed using computer graphics.

A human brain was first embeded in plastic. It was then placed on a microtome, which shaved off successive thin layers. The top of the block is photographed at each pass, and these frames may be shown in sequence as a movie. This process is called "cinemorphology". For the human brain film, the frames of a cinemorphology movie were carefully hand digitized, maintaining perfect registration throughout. The digitized sections were then reconstructed into a three-dimensional image using the graphics system at UCSD's Chemistry department, the very first Evans and Sutherland Picture System 1 built. The three-dimensional brain model was filmed using the Chemistry department's computer-controlled camera.

Hardware

The present system at QMLab consists of a PDP-11/34 and an Evans and Sutherland Picture System II. This system was acquired after the success of the brain film through a grant from Hoffman-La Roche Laboratories. In 1978, Phil Cohen traveled with the system to a number of conferences where participants were able to interact with the three dimensional brain model. Function switches and dials are used to interact with most of the software, although movie making is often more a matter of editing a textual script and then viewing the results.

The camera and filter wheel controllers were built by Robert Abel and Associates and interface to the PDP-11 through serial ports. The camera function box controls a 35 mm Mitchel camera which records an image off of a flat-face CRT made by Xytron. The CRT is slaved to the main Picture System monitor. Each frame is constructed using multiple exposures. Each color is filmed individually through a combination of three filters. Objects which are larger than the Picture System can display at once are exposed part by part. After all of the objects in a frame are exposed the film is advanced.

Software

The software that is used in animation falls into two categories: object generation and motion sequencing. Objects are generated in a number of ways. Some objects are generated using two-dimensional digitizing. The brain is a classic example of this approach. As the operator digitizes an object the picture system displays the data that has already been entered. A three dimensional object is created by stacking two dimensional contours. We have felt somewhat limited by not having general three dimensional object generation software.

Sign language data is also acquired through digitizing. In this case complex three dimensional patterns are captured using infrared cameras. The two clouds of points represent data for the fingertip and the wrist, the bar connects the two points for a given time. The rate at which the bar moves is very important, in a sense the pattern is four-dimensional.

We have also developed software for synthesizing upper arm movements for sign language research. Here the user interacts with the model by manipulating joint angles using dials. After actions have been specified using key frame and tablet techniques they are saved on disk for later replay. The sign language work is being done in collaboration with Ursula Bellugi at the Salk Institute and John Hollerbach at MIT.

Several objects have been generated using mathematical formula. Here a space-filling yinyang curve is being traced out. We have also generated toroids, spheres, dot fields and drum surfaces using this technique.

Finally, we adapt data bases from other sources. For example, all of the fonts in the movie are taken from a data base of the Hershy fonts.

The core of the animation software at QMLab is a program called movie written by Roger Sumner in 1978. movie is a compiler for an animation language called “moviecode”. Using moviecode, a user can construct scene elements consisting of one or more Picture System display files.

```
u = 0;
n = 1;
i = 2;
c = 3;
o = 4;
m = 5;
unicom = u n i c o m;
```

Here are some declaration statements taken from the moviecode for the UNICOM logo sequence you’ll be seeing later. The first six lines assign names to each of the Picture System display files passed as arguments to the movie program—each of these display files contains an image of one of the six letters in UNICOM. The last line defines a new element called “unicom” consisting of the six elements “u”, “n”, “i”, “c”, “o”, and “m”. As you’ll see in a moment, this hierarchical definition makes it possible to manipulate each of the six letters separately for the first part of the movie, then manipulate all of the letters simultaneously by referring to the “unicom” element.

```
rotx unicom,360,240;
roty unicom,-360,210,,30,0;
scalez unicom,-20000,240,22048;
```

```
scale unicom,-19000,240,20048;
draw unicom,384;
```

Here are some sample moviecode commands, taken from the latter part of the UNICOM logo movie. The first word on each line specifies what transformation is to be made to the element, and the second word, which element is to be transformed. The numbers following specify how much the element is to be transformed and over what time span. For example, the first statement causes the “unicom” element to be rotated about the x axis 360 degrees across 240 frames, or 10 seconds.

```
define(DUR,12)
define(END,384)
define(LETTER,‘
   roty $1,90,0,0,0,0;
   tranx $1,eval($2-1500),DUR,0,...
   roty $1,-90,DUR,,eval(END-...
   $4
   color $1,240,COLORNO,0;
   ’)
```

We often need to make similar transformations to a number of movie elements. To make this easier, we employ Unix’s m4 macro pre-processor. Here we define an m4 macro consisting of transformations which need to be applied to each of the six letters in “unicom” separately.

```
LETTER(u,-8000,BLUE)
LETTER(n,2500,RED)
LETTER(i,8750,GREEN)
LETTER(c,15000,GREEN)
LETTER(o,23000,RED)
LETTER(m,32000,BLUE)
```

We then call this macro on each of the six elements. In this case, the first argument is the element, the second argument is a displacement which moves the letter to its proper position in the word “unicom”, and the third argument is the color the element should be displayed in.

```
m4 mdef unicom.m | movie -m | color | O > unicom.i
interp -vgs slate list < unicom.i
```

Originally, movie was intended to be used both for previewing a movie and for filming it. It later turned out easier to modify movie so that it would output a stream of low-level camera control commands and transformation matrices when called with the -m (moviemaking) flag. This command stream is first filtered by color, a program which adds the low-level commands to control the color filter wheel, then it is passed through O, an optimizing filter which reduces the size of the command stream and optimizes filter wheel and camera movements. The resulting command stream is saved in a file for use later. With most of the movies made recently, the moviecode is first passed through the m4 pre-processor. The camera station hardware is controlled by the interp program, which interprets the command stream generated by the pipeline above.

Here is an example of a movie, the UNICOM logo sequence, being viewed in preview mode. Because of the limitations of the Picture System’s memory, we are restricted to simpler display files consisting of fewer vectors. In this case, we use single-layered letters rather than the stacked ones you saw earlier. The interp program can perform multiple exposures on each frame and can swap display files in and out of the Picture System’s memory as needed, allowing images much more complicated than these to be filmed. Also, the Picture System is only capable of displaying black and white images, leaving color for the moviemaker’s imagination. For the UNICOM logo movie, we used colored felt markers to help choose the proper color scheme.

Moviecode is often written with the aid of an interactive graphics program called compose. Then the moviecode is iteratively edited and previewed until the moviemakers are satisfied. Here we see a second version of the UNICOM logo sequence. An additional rotation has been added to enhance the tumbling in the beginning of the movie.

QMLab Sampler

What you are about to see is a sampler of films shot here at the Quantitative Morphology Laboratory over the past years. The first piece is about four minutes of graphics taken from the film “The Human Brain: A Dynamic View of It’s Structures and Organization” released in 1975. These scenes first demonstrate various structures within the part of the brain called the limbic system, then the entire brain is brought into view as the camera’s eye penetrates the surface, providing a view never-before seen of the brain from within.

The next sequence consists of images produced by the three-dimensional analysis of sign language movements being done by Jeffrey Loomis for Ursula Bellugi’s laboratory at the Salk Institute. These scenes include digital reconstructions of the actual movements of a person signing, and synthesized signs enacted by a stick figure.

The next four sequences are short pieces of animation done by various artists. The first is “On the Road Again”, by Phil Cohen and Roger Sumner, the second is “Dance”, taken from the work of Pat Gallagher, the third is “Zoom”, by Phil Mercurio, and the fourth is “Yin Yang”, by Jeffrey Loomis.

Following these are some images of two Unix networks. The first demonstrates the interconnections between the Unix sites at the campus of the University of California at San Diego. The second shows a map of the United States with arcs connecting the various Usenet sites. The final piece is the UNICOM logo sequence. These last two films were created by Jeffrey Loomis and Phil Mercurio. The music is by the Grateful Dead.