Easy Computer Graphics for Conservators

David Bayne, Shelburne Museum, June 1991

Introduction

The data that accumulates during the examination, analysis and treatment of objects must be processed in a constructive and succinct method. Computer graphics is an excellent way to present alot of data quickly and efficiently. As one graphics expert phrased it, "… we have to develop the knowledge that will translate a thousand words into one picture."[1] Computer graphics translates pages of description into simply understood images.

After understanding the graphics capabilities of a computer, it is possible to creatively expand into sophisticated areas of analysis. Computer graphics is of course excellent for presentations, as anyone who watches TV sports can tell you. But the potential exists for applying some of the same tools to answer some interesting questions about museum objects. For example what are the differences in the proportions of English casepieces and the high chests made in Philadelphia? Another example might be trying to design a replacement for a damaged or missing decorative element. After entering related examples into a computer, possible designs for the missing piece could then be manipulated in a graphics program until a correctly proportioned replacement is found. Graphic presentations are visual phenomenon that stimulate the brain in different ways than words or tables of data.

I will first discuss some of the shared features of the graphics programs I have used. In general, there are two methods of entering visual information into a computer. The first is through a mouse and a keyboard and the second is by the use of a scanner. After discussing these subjects, a case history exemplifying the analysis possibilities is discussed.

Computers and Programs

Computer graphics is the most effective method of presenting complex data about visual phenomena. The leading small personal computer in this field is the Macintosh by Apple Computer. The IBM type of machine can do an excellent job, although it is not as intuitive nor do the programs share as many features as the Macintosh. Virtually all of the following discussion is based on the use of a Macintosh SE with a 20 megabyte hard disk. The SE will handle all of the programs mentioned except for the color applications which require a bigger machine. Of course the more memory and the bigger the screen, the better the performance.

Focusing on Macintosh may be a problem since many conservation labs are devoted to the IBM format. However with a little inquiry Mac users can be found, often within the stodgiest IBM institution. For example the marketing department of the Winterthur Museum uses Macintosh although the full time computer staff does not "support" it. Other accessible Mac sources, are college and university computer facilities. These are often free, and come equipped with student counsellors or other friendly helpers. University computer centers often are loaded with machines more powerful then what can be afforded personally. If you are lucky you may even find a computer geek that will take a helpful interest in your project. Depending on your area there are various outfits that will rent computer time. For example in Burlington Vermont a computer store and a do-it-yourself graphics outfit will sell you time with their Macs, scanners, and software. Finally, it is possible to take one or two night courses that will not only teach you about a particular application, but will also put you in touch with people of similar interests.[2]

Some of the most basic graphics can be found within word processing programs. For example using Wordperfect graphics on an IBM machine, rectangles, and horizontal and vertical lines can be drawn to create simple representational images. These types of tools can add zing to a report or can be used to create bar graphs. A little time spent practicing with the manual and the program may be an interesting introduction to computer graphics with a minimum of fuss and expense.

For slightly more advanced graphics, a specific program is necessary. There are a vast array of possibilities. Most of these applications duplicate what can be done with pencil and paper, and in some cases it might seem easier to dispense with the computer. However the many small advantages of computer drawing often add up and make it worthwhile to develop a complete palette of skills. A few common principles motivate all Macintosh graphics programs. Most of these programs share the same rationale, and the motions and commands from one program are transferable to other applications.

A drawing program, such as Macdraw II[3] is excellent for beginners. It is readily available and it creates some interesting and useful images. A handheld mouse guides a variety of different drawing tools on the screen. In addition to lines and four sided figures, circles or ellipses of any dimension are drawn. With these tools, it is impossible to accidentally draw a trapezoid or lumpy circle. Furthermore the program can tell you exactly what the size of the object is. For example, if you need a rectangle that is 2 5/16 inches by 4 1/8 inches, the rulers can be set and the rectangle drawn **precisely** and quickly. If a drawing needs to be converted to centimeters or miles; a push of a button does the job.

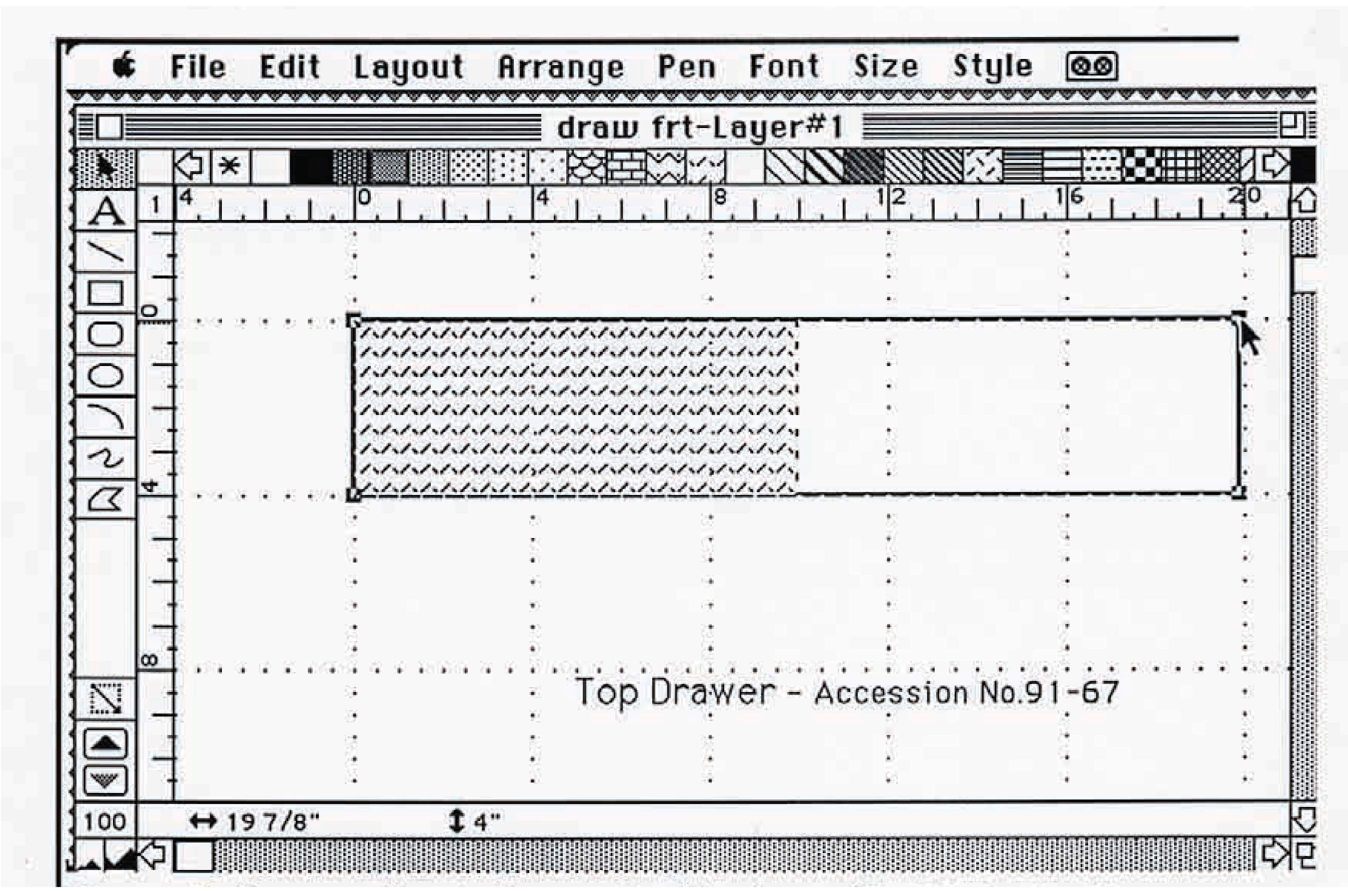

Figure 1 Drawer Front Drawn in Macdraw II. *This is the Mac screen after drawing a drawer front. The series of boxes across the top are the various "colors" possible. The boxes on the left edge, are the tools available. The drawer front was drawn with the rectangle tool. Both beneath the color boxes and on the left side is the scale ruler for this drawing, 1″=.25″. At the bottom of the screen, to the right of the "100", is the size of the drawer front, 19 7/8″ x 4″.*

After drawing a few lines, the lines may then be grouped together. Once the lines are together, the entire assemblage functions as one unit. The drawer pull in Figure 2 was drawn by grouping two small circles with one heavy line. If the image needs to be larger or moved, then the all the lines stay together. Complex representations can be formed by compiling a variety of sub-assemblies. This hiearchical arrangement of nesting images can be very useful since things can be unstacked if needed or simply moved *en masse.* Understanding when to group lines is one of the acquired joys (or frustrations!) of graphics. Finally a library of useful shapes or images can be stored and pasted in many different drawings.

For example if you often draw Chippendale chairs it would be handy to have a few ball-and-claw feet or various splat shapes on hand, to use as necessary.

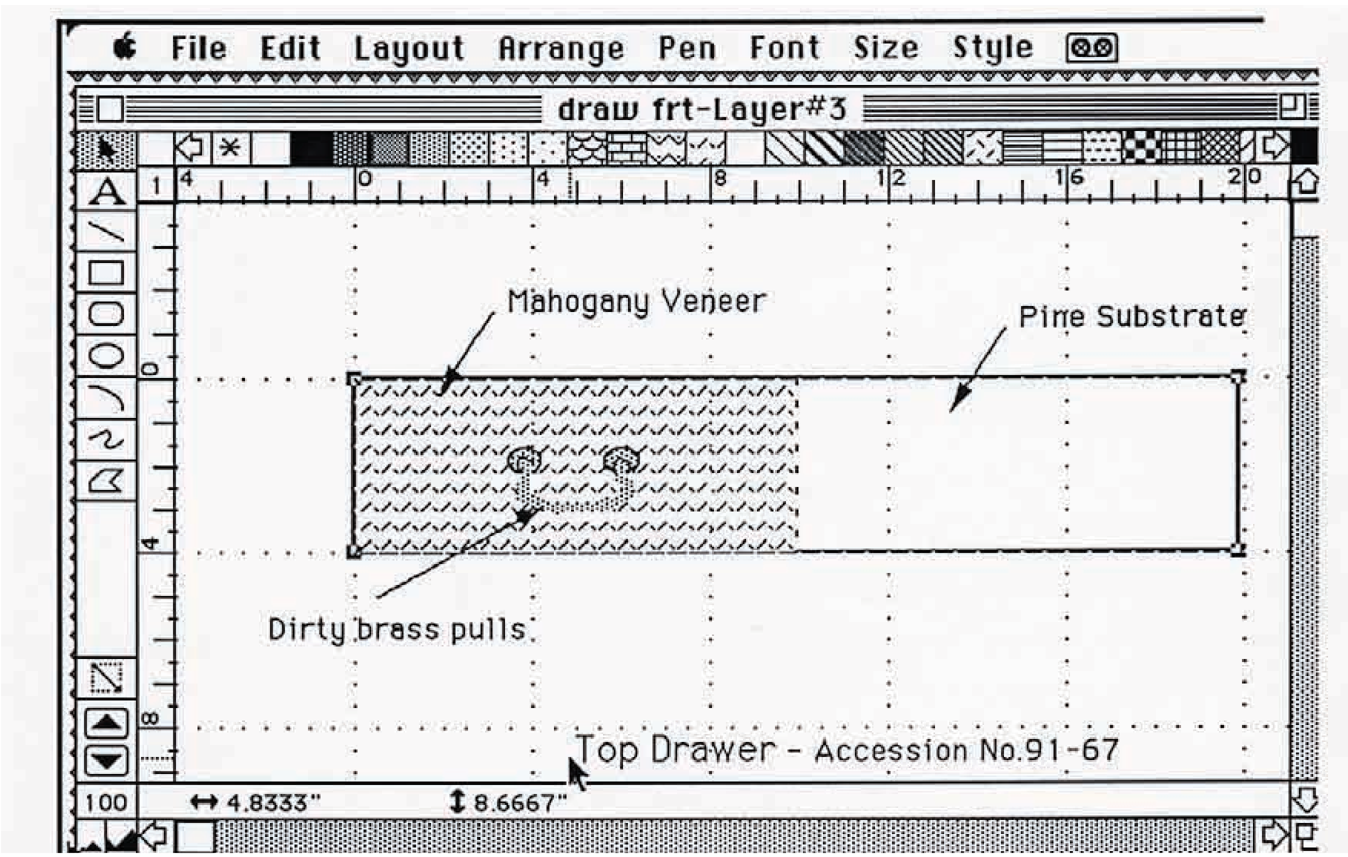

Figure 2 Groupings and Layers. *The brass pull was drawn in Layer 2 with two circles and a line and then grouped together. After grouping the pull was moved into position. In Layer 3 (identified at the top) the arrows and labels were added.*

A feature found in many graphics programs are layers, A layer is the electronic equivalent of a sheet of tracing paper that is absolutely transparent, never moves, or never responds to temperature or humidity changes. A screen image can be overlaid with many separate layers. In the upper layers the image can be added to or traced over with all the drawing tools, but the original is not changed. It is possible to use one drawing over and over with different layers for different purposes, similar to a template. A drawing of a drawer can have the parts identified in one layer, the woods in another, and the colors in a third. Layers can be made invisible if necessary so images do not become cluttered. Finally, layers can also be locked so that the entire stack moves together.

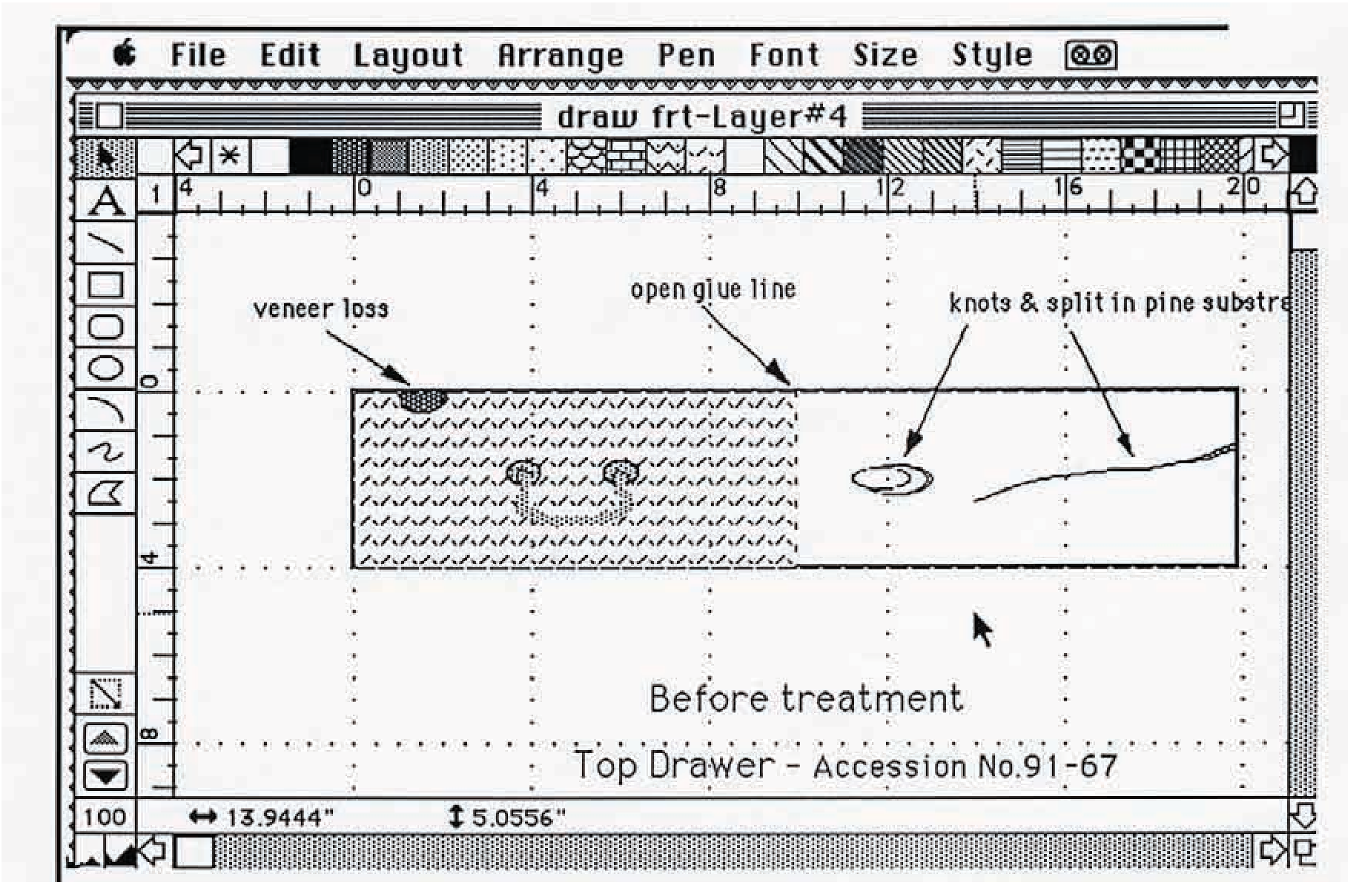

Figure 3 Drawer Front Before Treatment – Fourth Layer. *The third Layer with the arts labeled is now invisible and the damaged areas identified.*

Besides being able to precisely draw scaled geometric figures, MacDraw II and similar programs can zoom in or out to make the drawing or details of the drawing any size. (See Figure 4) The procedure resembles using a magnifying glass on a drawing board. For example, if it is necessary to precisely abut a square tangent to a circle, the point of tangency can be magnified on the screen and the two shapes maneuvered until exactly one point of the circle touches the square. The computer can magnify part of the drawing on the screen, but the rest of the drawing stays the same size. It is also possible to make the entire drawing bigger or smaller in relationship to the paper it is drawn on. On each line or drawing there are various points, "handles," that can be snagged with a pointer operated by the mouse. The drawing or parts of a drawing can be made bigger or smaller by "grabbing" these handles (the small black squares at the corner of the drawer front in Fig. 1) and moving them with the mouse. If all the handles are grabbed at once, then the entire drawing can be made bigger or smaller while still preserving the correct proportional relationships. In the bar at the lower edge of the screen the size changes are relayed. Pulling on one handle will stretch or distort the drawing. Resizing can result in a drawing large enough to cover many sheets of standard paper. For example with MacDraw II it is possible to make a drawing 100 inches X 100 inches that would cover 130 pages of 8 1/2″ X 11″ paper. However there may be memory limitations if a detailed drawing is made too big.

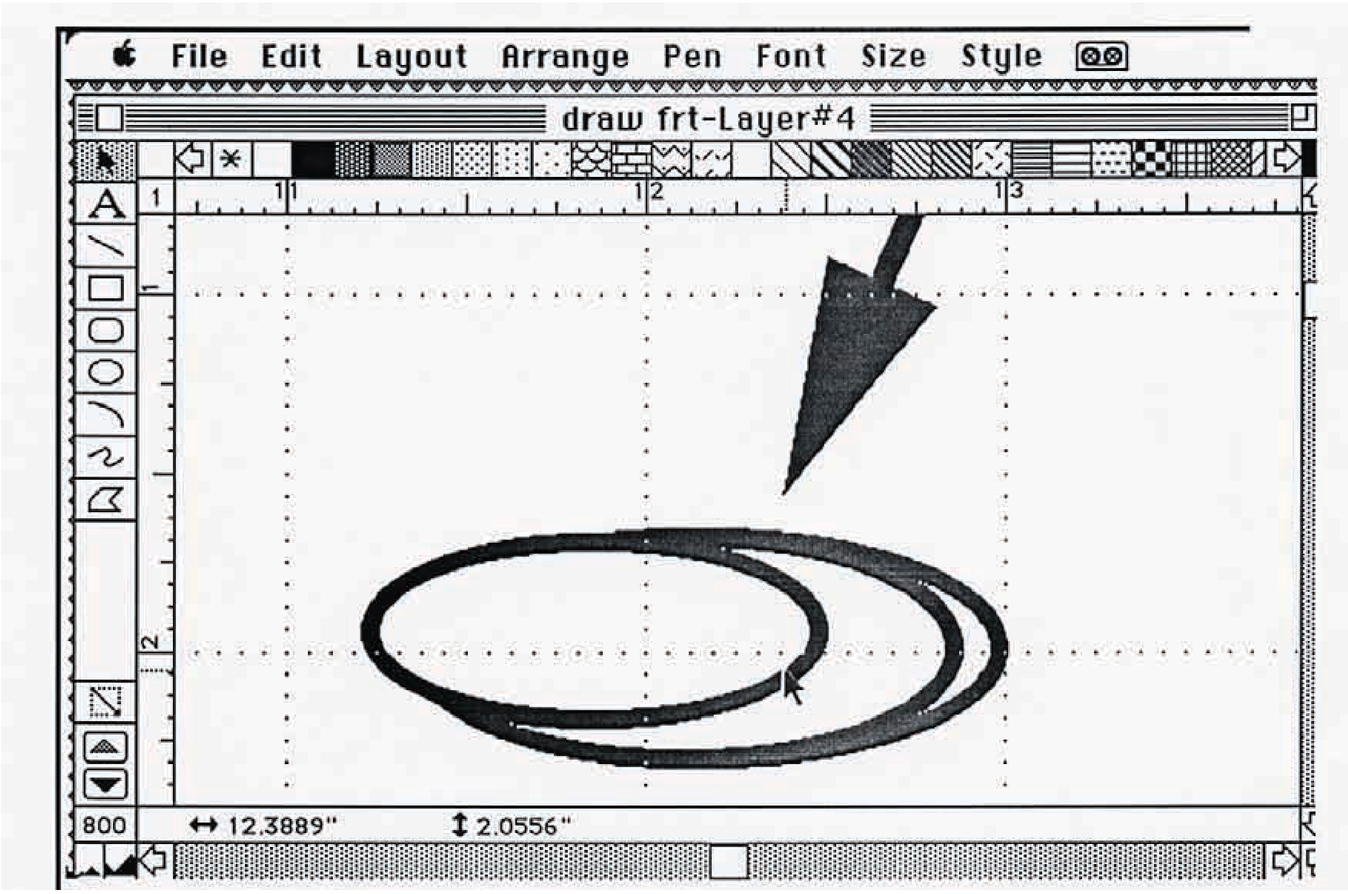

Figure 4. The Drawer front Magnified. *The knot in Figure 3 is magnified 800% as indicated by the number in the lower left, The two boxes below the number control the amount of magnification.*

Linking magnification with editing creates a powerful tool. Without years of practice, freehand drawing with a mouse is difficult. But correcting mistakes on a computer screen is easier than correcting with paper and pencil. Individual lines can be selected and removed very quickly without smudges or eraser crumbs. Reshaping occurs in a variety of ways. Objects can be stretched or compressed, rotated, and transformed. Also they can be duplicated, copied, and pasted similar to the procedures in a word processing, program. The magnification abilities are very useful in these situations and allow minute adjustments.

The above discussion outlines some of the features found on many Macintosh drawing programs. Obviously most of these functions duplicate the processes of a draftsman. Another type of program imitates a painter. In these programs color (either actual or representational with black and white screens) is manipulated. Tools such as "brushes" or "spray cans" can be used to spread an amazing variety of patterns. These can be used to create an image, or to "color" an image drawn in another program. SuperPaint[4] exemplifies a popular program that includes a drawing and a painting application together.[5]

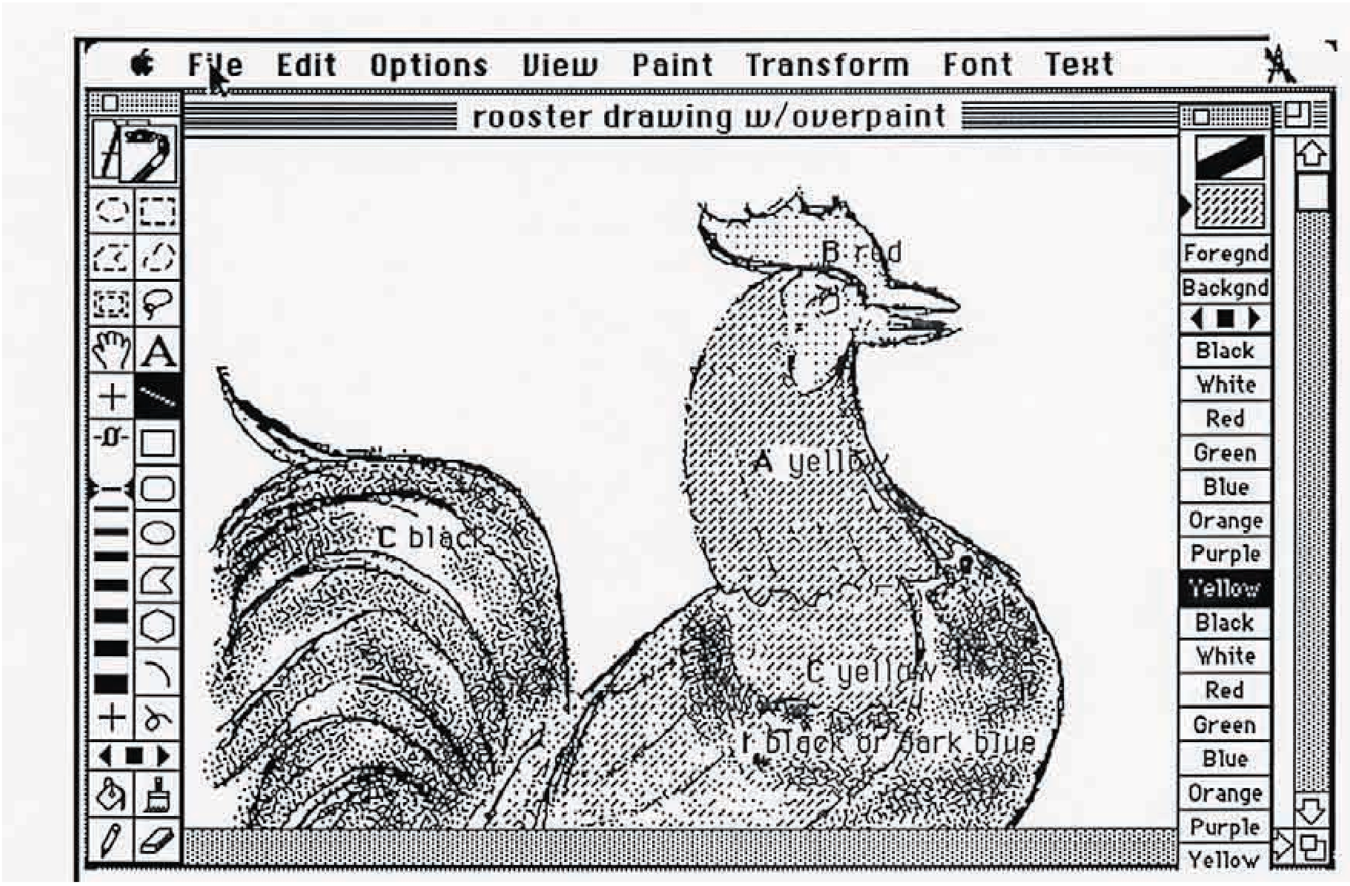

Figure 5 Rooster Drawing in SuperPaint. *The drawing was first made on lined paper and then scanned into SuperPaint with a flatbed scanner. Within the program the lines from the paper were removed, some of the drawing was improved with magnification, and then colors were represented. The bold letters are the microscopy X-sections used to determine the colors.*

An elaboration on the two dimensional programs, are three dimensional or even four dimensional drawing programs. Although their uses are limited for conservation, they are fascinating. Through a variety of ways, three dimensional objects can be drawn in these programs and then viewed from any angle. Perspective and shading can be added. Finally changes in time can be portrayed with animation. These are not the ultra-sophisticated drawing programs that architects and interior designers use, but are cheaper and more accessible versions for a personal multi-purpose computer. A program with these features is Super 3-D.[6] With Super 3-D, it is possible to draw a chest of drawers and then turn it until a 3/4 view is obtained. In this way two sides can be described at once. This economizes drawings and words but, in practice, is awkward. It is probably easier to draw the two sides in separate drawings.

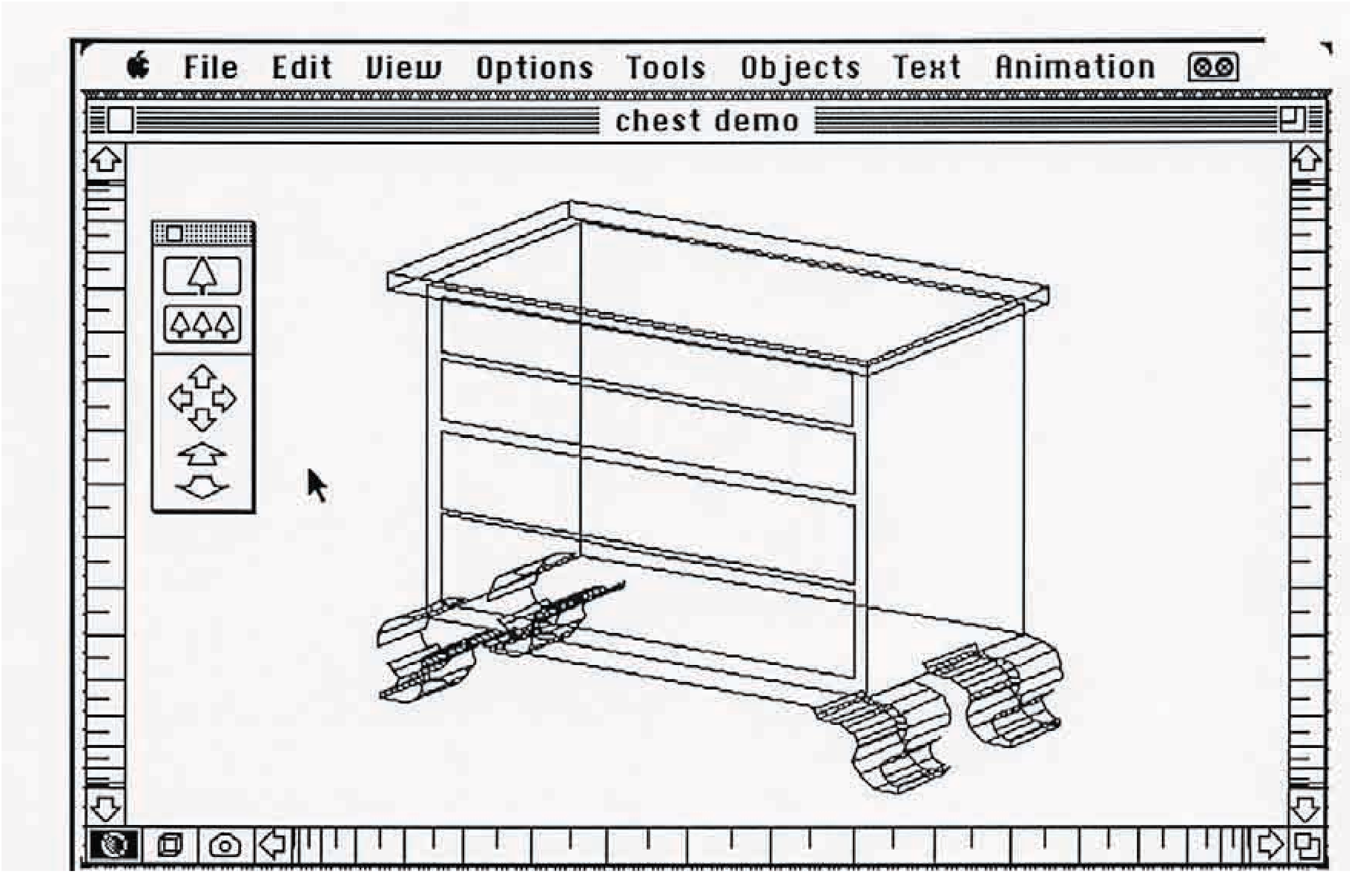

Figure 6 Chest of Drawers Drawn in Super 3D. *The scales on the left, right, and bottom are controls for rotating the z, x, and y axis. The three small boxes in the lower left comer are to choose whether the world, the object or the viewpoint is changed as the controls are operated. The menu on the upper left controls the zoom in, zoom out; look left, right, up, or down. The two arrows on the bottom of the menu move the camera in or out. The chest can be viewed as a wire frame model (this example) or as a solid with a variety of lighting conditions.*

Scanners

Besides drawing with a mouse and keyboard, another method of entering visual data is by scanning a previously created image. Computer graphics relies on a scanner for this purpose. There are a variety of machines available but the most useful is a flat-bed scanner.[7] An image is laid upside down on a glass plate, a light comes on and presto! The image is on your computer screen. Scanners and Fax machines have many things in common. Both of them take an image, either color or black and white, and with light convert the image into a series of off-on electrical impulses. The electrical signal can then be encoded into a computer language. For conservators this means that an image after being created with paper and pencil, (with which most of us are fairly dexterous) can be scanned into a drawing program and then further manipulated. For example the drawing of the rooster (Figure 4) was done on scrap lined paper and then scanned into SuperPaint. With the program the lines and other mistakes were corrected. This was much easier then trying to draw the rooster directly with a mouse. Finally a layer was used to identify the parts, colors etc., similar to the drawer.

Pictures other then drawings can be fed into a computer. For example a black and white photograph of the rooster could have been scanned instead of the drawing. However a scanner records the entire photograph and that might exceed the memory of your computer.

There are ways around this problem since often the entire piece of paper is not of interest. For example after scanning, photographs can be traced, and then the traced layer used as the important image. In this way very good drawings of an object can be created without any artistic skills whatsoever. A piece of furniture in a photograph can also be isolated from a room setting by carefully cutting the object out of the photo on the computer screen. Since only the furniture is of interest, that is the only thing that is saved. Finally the scanned photo and the layers above can be used together to create a composite image. For example, colors can be added to the various parts of the photo. After printing the color overlay with the scanned photograph, a good
representation would be generated of the object as it looked at a particular time.

By using the scanner to input the image, the editing over the drawing functions of the graphics programs are stressed. After a drawing is entered into a program it can be magnified, traced, and re-proportioned in a variety of ways. Of course this is not recommended with traditional drawing materials and period documents. It is also possible to eliminate fly specks or mold spots that might be confusing the image. However if the drawing is then printed or published, it might be impossible to determine how the original has been altered. It is important to be aware of how misrepresentations happen. Alterations of images can occur accidentally and may jeopardize the validity of analytical arguments.

A flatbed scanner uses images on paper. With a slide scanner a standard 35 mm slide is projected on to a video camera and encoded into a graphics program. It is also possible to use print film negatives as a slide. Some slide scanners convert a negative into a positive on the screen. By entering slides without first generating a print on paper, many variables involving developing can be circumvented. A possible museum application of a slide scanner is to compile a slide library of an entire collection. The National Gallery has made some efforts in this direction.[8] Of course with a computerized library it would be possible to share slides of different collections through the use of a modem.

Before leaving the subject of input devices, there are other methods of entering images into a computer. A video camera can be used as an input device with the right types of software and electronic connections. Most of this equipment is too complicated and expensive to be useful for all conservators, but the techniques do exist and costs might come down.[9] The links between video cameras and computers suggests many different possibilities for conservation.

One application of video for conservation, is the use of a camera with a microscope. A video camera can record a picture of a microscopic sample on to a still video recording disk or directly into a computer. In the computer the information about the image can be manipulated in a variety of ways. A video camera needs to record many details before it can fully portray it to the human eye. It is possible to take some of that information out of context and use it for creative analysis. Some of the possibilities are discussed below.

Analysis

The above discussion highlights some of the computer graphics features useful for communications and design. Although effective presentation is an important skill there are analytical uses for graphics. In order for a computer to present an image, information about that image has to be read and recorded by the machine. Once that information is in the computer though, it can be used for a wide variety of experiments. The analytical potential that exists with computer graphics is dazzling. By creatively interacting with the data on the screen, it is possible to gain new insights into the materials and objects that we are responsible for understanding.

I will next discuss three examples that combine the techniques outlined above and explores some of the analytical possibilities.

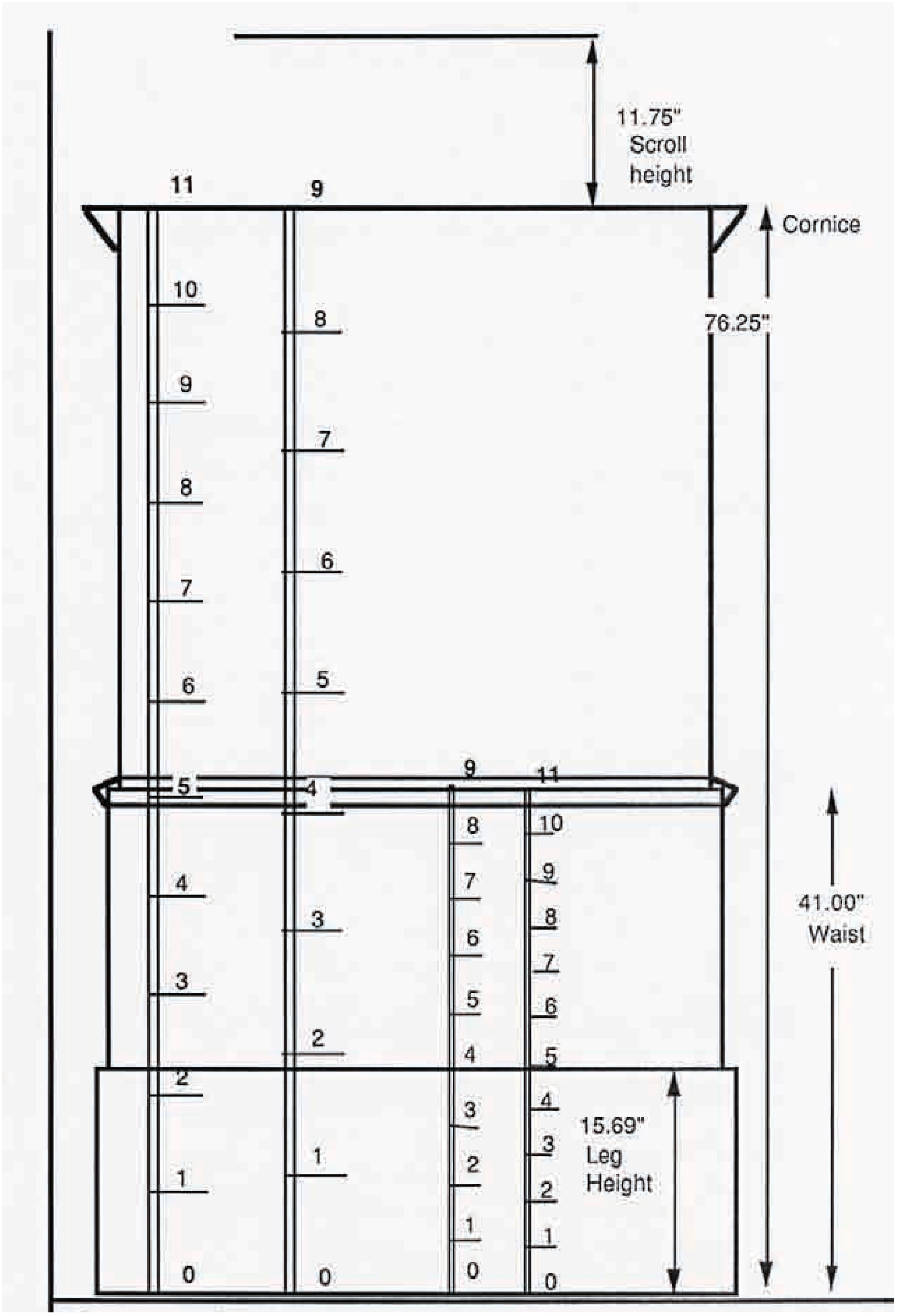

Figure 7 High chest with rulers. *The heights and widths of the three main parts of a high chest (Metropolitan Museum of Art #18.110.60) drawn to scale. The division of the cornice height into 11 parts (the rulers on the left) results in a 5:6 ratio of the lower case:uppercase. A 9 part division of the waist height gives a best fit of 4:5 for the height:lower case height.*

1. Proportional Analysis

Scholars and designers try to quantify “good” proportions. For example, Philadelphia Rococo casepieces are often described as prime examples of American 18th-century furniture. What makes them so special? One way to approach this subject is to measure many different pieces and determine what, if any, are the characteristic dimensions.[10] After compiling the data, the whole number relationships between the parts can be determined with a graphics program. For that matter, many other relationships between the parts can be examined. For example an eleven part scale similar to an Ionic column can be superimposed over a scaled drawing of a high chest. By using the computer program, the ruler can be expanded or compressed or divided to fit the outlines of the piece of furniture. This is especially useful for unusual ruler divisions, such as ninths or elevenths.

In other words experiments using a computer graphics program can test various hypothesises. For example how does a Philadelphia chest-on-chest compare to the examples from period English design books? Are there any comparisons with American period drawings? What are the other possible regional or period comparisons?

The first step in comparing the Philadelphia data with English published drawings was to photocopy a plate from a 1754 drawing by Thomas Chippendale[11] The most complete, existing, period drawing of a Philadelphia chest-on-chest is by Samuel Mickel dated 1766. This was also photocopied. Both photocopies were then scanned with an Applescanner into MacDraw II[12] (see Figure 8). Since the complete images required a great deal of memory, the essential outlines of the cases were traced off of the drawings into separate layers. (Figure 9) The tracing was very accurately done by making the traced line a different color from the original. Magnifying the process insured that the traced line exactly corresponded to the outline of the upper and lower cases. Any errors could be corrected point by point as necessary. The two tracings were separated from the original, made the same size and placed side by side. The proportional relationships between all the parts was maintained by the computer program during the resizing. Once this was done, the standard Philadelphia chest-on-chest (determined by averaging 13 examples) was overlaid onto the traced images. In Figure 9, the casepieces that were built in Philadelphia maintained the same 5:6 proportions between the upper and lower cases as the Chippendale and Mickel drawings. However the widths of the American pieces are remarkably narrower.

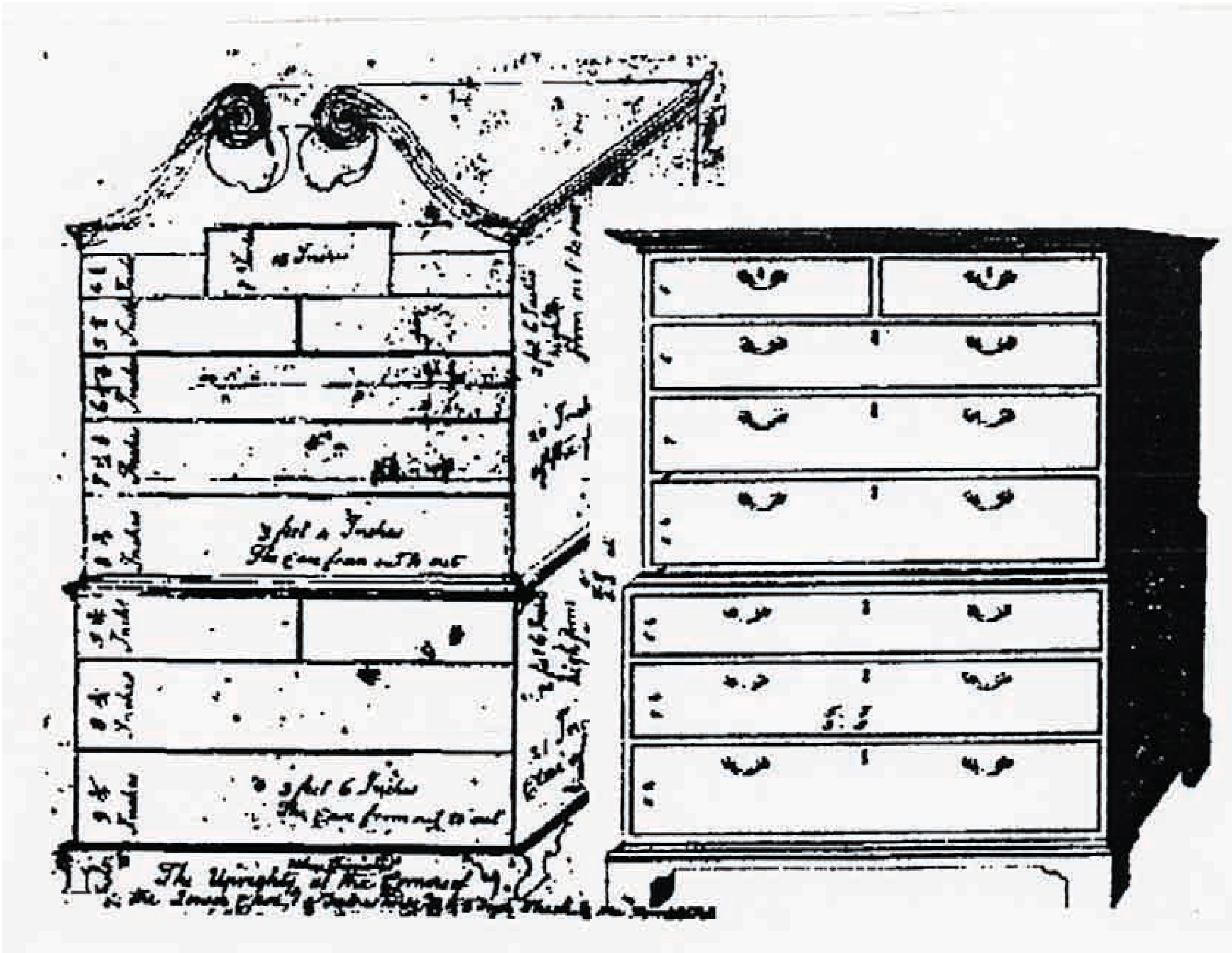

Figure 8 Mickle and Chippendale Drawings Compared. *Both the Mickle drawing (left) and the Chippendale engraving were photocopied from the sources and scanned into the computer to produce this comparison. The scanned images were then traced to generate the outlines used for subsequent comparisons.*

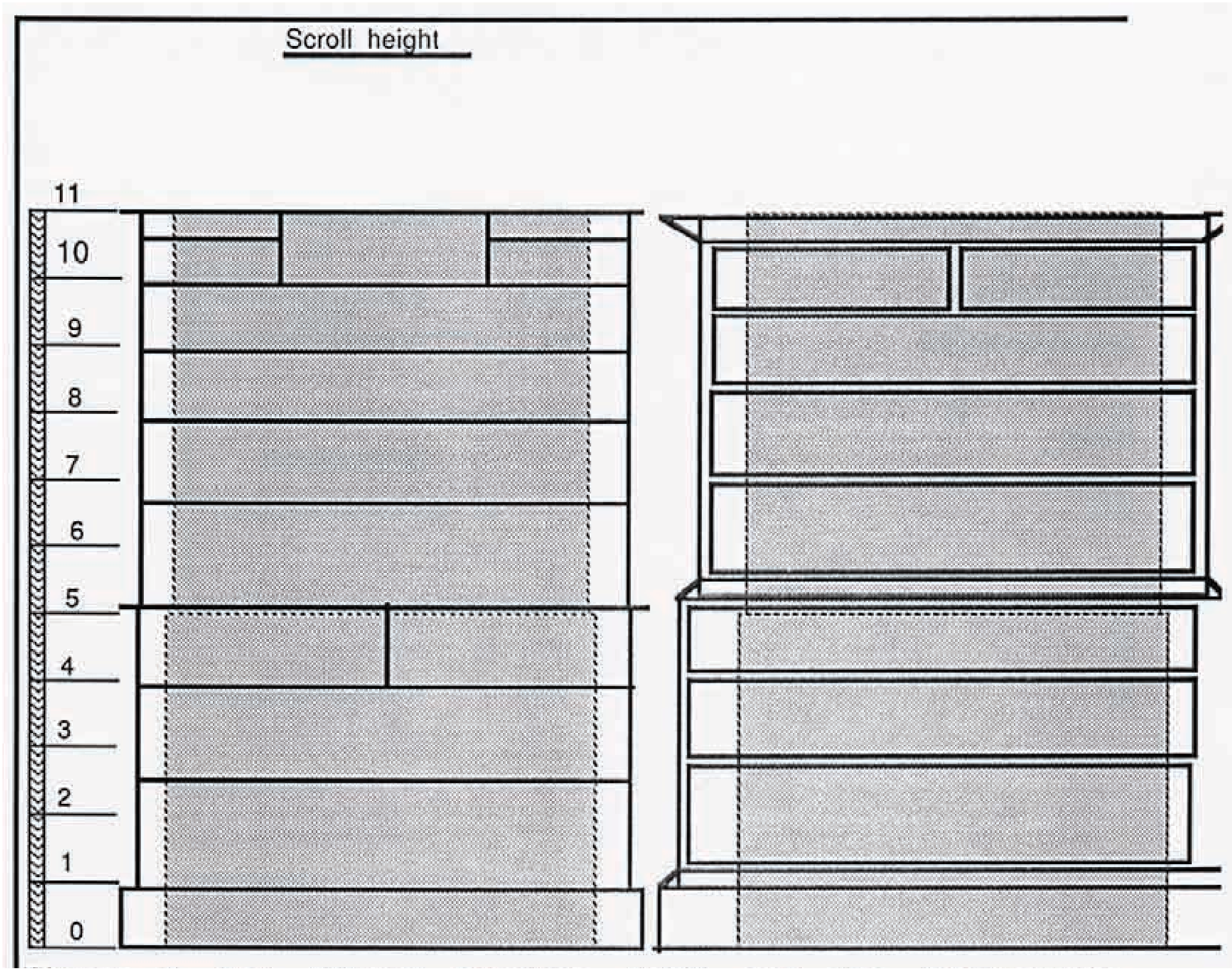

Figure 9 The Mickle Drawing (left) and the Chippendale Engraving (right). *The scanned images of the drawings were traced and a ruler of parts applied. The average dimensions of the measured Philadelphia examples are represented by grey boxes. Although both drawings and the measured pieces share a 5:6 ratio, the American pieces are noticeably narrower than both of the drawings.*

More information is obtained by using another kind of ruler. A two-dimensional ruler relies on the fact that concentric rectangles share common diagonals. For example two 2:1 rectangles of different sizes but with a 2:1 relationship between the sides will, when superimposed, have the same diagonal. It is easy to make this type of ruler with a computer drawing program. First, draw as accurately as possible (use magnification) a rectangle with the correct proportions. Extend the diagonal of the rectangle beyond the perimeter and then draw as many rectangles as desired that have two vertices intersecting the diagonal.

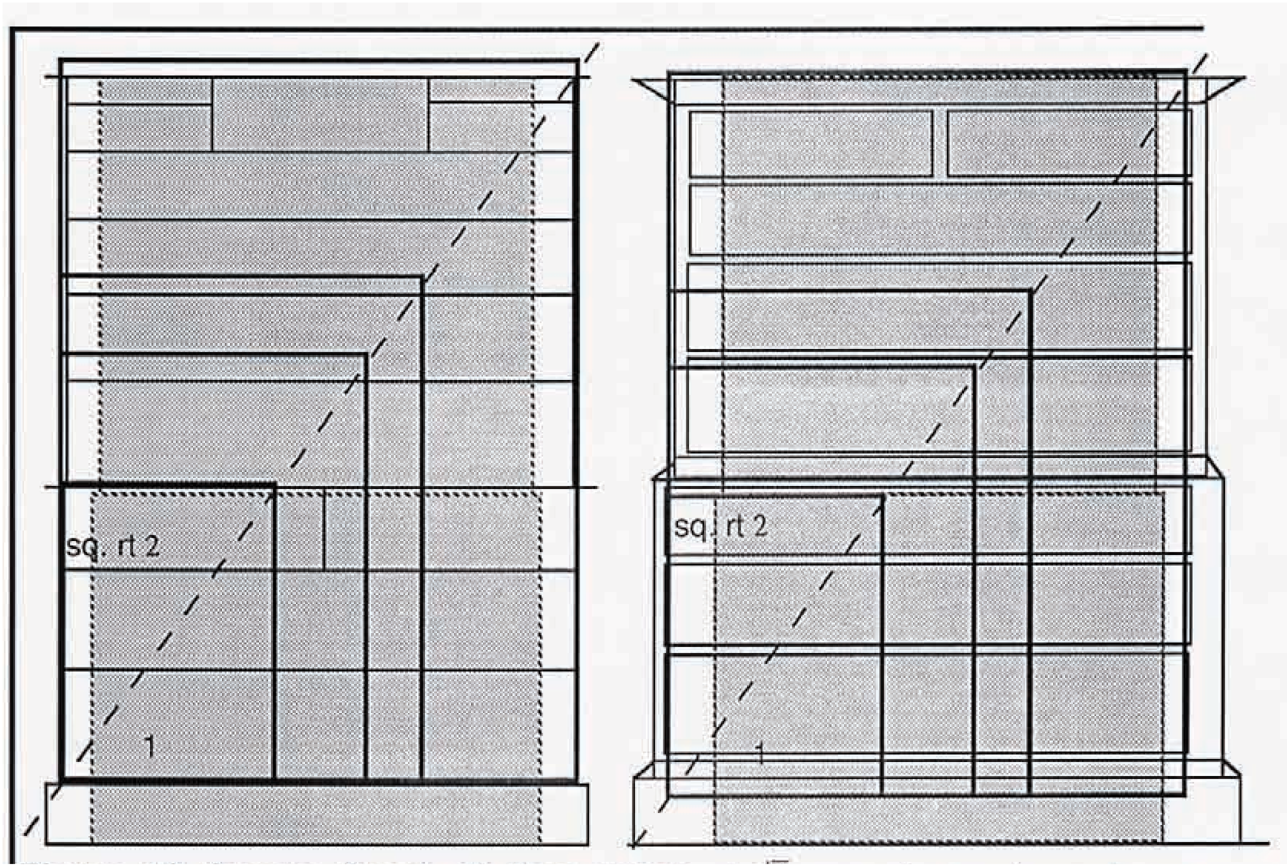

Figure 10 Square Root of Two rulers. *A √2 rectangle superimposed over both traced drawings and the "average" Philadelphia chest-on-chest (the grey boxes). The Mickel and the Chippendale drawings are both closer to √2 proportions than the American examples.*

The two dimensional ruler can be superimposed over any rectangle. If the ruler's diagonal intersects the vertices of the experimental rectangle then the rectangle has the same proportions as the ruler. This is an especially useful technique for irrational proportions such as the Golden Section or the √2. A √2 ruler was superimposed over the Chippendale and Mickel tracing. (Figure 10) The rectangles formed by the chest-on-chests are close to a √2 proportions. The Philadelphia casepieces do not have these proportions. Although it is possible to determine if a casepiece has √2 proportions by direct measurement, the graphical approach is quicker and the result intuitively understood. The same method could be used to check to see if a piece of furniture has Golden Section proportions. No Golden Section proportions were found in the Philadelphia or English casepieces

2. Replacement pieces

Another graphics application that is more directly related to furniture conservation is the design of replacement parts. Often the design of replacements for a missing finial etc, relies on witness marks and comparisons with similar examples. Of course the development of an eye for the correct look is also necessary. Computer graphics can help with this process. By following some of the same graphics procedures used for the proportional analysis it is possible to develop many good designs for a replacement part.

3. Color graphics and Microscopy

When microscopic X-sections are examined, much of the interpretation relies on color recognition. Color recognition is also an important part of computer graphics. With the right combination of hefty computer, scanner, color monitor, and software all sorts of images are created for advertising, television, and art. These same techniques have the potential for helping the conservator identify and analyze X-sections. Although the equipment is expensive, it is cheaper and more readily available then a spectrophotometer rigged to look through a microscope.

The colors in a X-section relate to the chemical composition of the material. If the composition changes then the color changes. This is obvious with white light. A red iron oxide is both chemically and chromatically different then vermillion. The correlation between chemistry and color is also true when ultraviolet light is used. An obvious example is the orange fluorescence of shellac and the yellow fluorescence of a natural resin varnish.[13] But is it possible to more precisely describe the color differences using a color graphics program? Would being able to describe the colors exactly help separate different types of varnishes? Another application would be to determine if a layer that appears to be untouched by a cleaning method is actually the same color as before cleaning. If the color had changed, it may indicate a change in the material as a result of the cleaning. After compiling suitable reference colors, it might also be possible to determine the age of a sample.

Color identification is a fundamental part of any color graphics program. For example programs such as ColorStudio and Photoshop[14] can identify colors in four different ways. For example the red, green, and blue components can be used or the Pantone System equivalent. With the right type of monitor, 16 million colors are possible. Graphics programs were designed for mixing colors and applying them to an image on the screen. By entering the white light X-sections into the color graphics program, it is possible to identify the colors of an object at any particular point in it's history. A colorized image of the piece could then be made.

UV illuminated sections can also be analyzed with color graphics. By determining the colors of the fluorescing media, comparisons can be made that might indicate changes in the material. This could be crucial information during a treatment. Once the X-section image is entered into the computer, the color measurements can be preformed by placing a drawing tool over a particular spot and clicking the mouse. This is a very quick procedure.

As a limited trial of this technique, two X-sections taken from the rooster mentioned above, were analyzed with ColorStudio. Since through-the-microscope video equipment was not available, color prints were made with a standard 35 mm camera attached to a Nikon Epiphot microscope with a 540 excitation filter cube. All the prints were from the same roll of film and were processed in the same way. A color scanner (Microtek 300Z) was used to input the 3X5 prints into a Macintosh IIfx computer. Seven to ten color measurements were taken of four different varnish layers, and the percentage of red, green, and blue components were recorded.

Two different X-section samples were used. The four varnish layers that were measured, are in the same relative location in the sample. Presumably the materials in the same layer, but different sections, share the same history. By comparing the fluorescence in the layers of the two sections, potential differences in the materials can be found. Although the chemical composition of the layers may have been the same when they were first applied, it is conceivable that they would have aged at different rates depending on exposure to environmental variables.

Two prints were of the same X-section but at different camera exposures. By comparing the colors from the two prints, a preliminary measure of the effects of film processing and exposure could be obtained. The exposures were approximately 1 F-stop apart and the color differences in the prints were barely perceptible by eye.

Table 1 Color measurement Data. *The average %'s of red green, and blue are presented for each of the layers. The % is for all the color possible of that type. For example 50% red is out of 100% red. In other words white light is 100% red, 100% green, and 100% blue. Very low percentages indicate almost black or no light. The sample area was approximately 1/4" in diameter.*

		% Red	% Green	% Blue	Data pts
X-section 1a	Bottom layer	57	37	0	10
	Middle Layer	71	42	0	10
	Orange Layer	55	35	3	9
	Top layer	69	42	0	9
	Bioplastic	5	4	0	7
X-section 1 b	Bottom layer	66	41	6	9
	Middle Layer	74	44	6	10
	Orange Layer	63	38	9	9
	Top layer	70	43	7	10
	Bioplastic	6	5	4	7
X-section 2	Bottom Layer	73	44	7	10
	Middle Layer	77	46	7	10
	Orange Layer	70	42	6	10
	Top Layer	68	44	7	7
	Top Trial 2	73	45	7	7

The data suggest that the graphics program differentiated between the two prints of the same X-section (X-section 1 a&b above). The color measurements for b are slightly brighter as expected. The measurements taken of the Bioplastic indicate how the system works. To the eye the Bioplastic is a very dark green. With the computer program the low percentages of red, green, and blue indicate how dark that area is. The higher percentages in print b reflects the increase in the light exposure.

If X-sections 1 and 2 are compared, very little difference between the four varnish layers is revealed. Some similarities were anticipated, but it was expected that two of the layers would be different. The orange layer is obvious to the eye, but using the graphics program, there does not seem to be any difference between the orange and the other layers. The color measurement data of the orange layer in both samples is approximately the same. Unfortunately, this was a very small data sample and with more extensive measurements a difference may be found. Probably the main problem is the method of entering the image into the program. Scanning a conventional color print is not the most accurate method of entering colors into a graphics program. There are many different variables to discover and predict. A much more direct method of getting the image into the computer would be with a direct video link, if that equipment was available.

Ideally a through-the-lens colorimeter or a spectrophotometer should be used to measure colors. However the advantage of using a computer graphics program is the low cost and availability of the equipment. Although the color software and the Mac II fx is considerably more expensive then the Mac SE system, they are still off-the-shelf items. It might be possible to use the color graphics in situations where the more sophisticated equipment is not available. The ease with which color can be measured using the graphics techniques suggests the use of statistical analysis to detect small variations in the layers. Of course color measurements taken with a graphics program should eventually be collaborated with a spectrophotometer or other device.

Conclusion

Computer graphics offers an amazing array of tools and techniques. This technology is applicable to many parts of conservation. Information can rather easily be entered into a program with either a mouse or a scanner. Within the available programs the visual image can be manipulated for many different purposes. Computer graphics applied to conservation will not only increase our communication skills, but graphical analysis can expand our abilities to understand the objects and the materials that we treat.

Footnotes

1. Aftab A. Mufti, *Elementary Computer Graphics* (Reston, VA: Reston Pub, 1983) p.1.
2. A good general reference to Macintosh computers that includes a chapter on graphics is *The Macintosh Bible* 2nd edition. Edited by Arthur Naiman (Berkeley CA., Goldstein and Blair, 1989)
3. Claris Corporation. 440 Clyde Av. Mountain View. CA. 94043. 415:962-8946.
4. From Silicon Beach Software, Inc. P.O.Box 261430 San Diego, CA 92126. (619) 695-6956
5. See below for some ideas on how to match the colors of the overlay with the colors from the X-sections.
6. Also from Silicon Beach Software, Inc. P.O.Box 261430 San Diego, CA 92126. (619) 695-6956. For more on 3-D programs see David L. Peltz "3-D in Perspective" *Macworld* December 1988, p.108.
7. For more see John Ronga and Luther Sperberg "Pick from a Growing Field" *Macworld* August 1990 p.152. Also Steve Roth "Grade A Gray Scalc" Macworld October 1990. p. 203.
8. For example see Karen Sharpe" AXS/Optech: Quick Disk Pix Tricks" *Computerland Magazine* September/October 1990 p. 22.
9. For more see the excellent article by John F Asmus. "Digital Image Processing in Art Conservation" *Byte* March 1987, p.151. Also see Peter S. Marx and Franklin N. Tessler "Prime Time Video: A Guide to Video Hardware for the Mac," *Macworld* September 1990. p. 206 and Peter S. Marx and Franklin N. Tessler. "Mac Video. Take II" *Macworld* February 1991. p. 178.
10. David Bayne "The Proportions of Philadelphia Rococo Casepieces" unpublished Master's Thesis, Antioch University.
11. Peter Ward-Jackson *English Furniture Designs of the Eighteenth Century* (London: Her Majesty's Stationary Office, 1958). Figure 73.
12. Unfortunately a photograph of the piece to be investigated can not be scanned into the computer and measured. There are too many different photographic distortions even with a head-on shot. The actual measurements should first be used to draw the relevant outlines. This is not hard with a program similar to MacDraw II. The completed outline for a high chest can be done in less then a half hour from a table of measurements.
13. These are the colors seen with an excitation of 540 nm or "green" light.
14. Compared and evaluated in Lon Poole, "Pictures Perfected" *Macworld* January 1991, p.144.