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Computer Graphics for Multimedia and Hypermedia Development

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ABSTRACT

ONE OF THE FOREMOST DEMANDS of multimedia and hypermedia development is in the visual aspect. The adage that most developers are familiar with is that content is king. Regardless of the product's communicative purpose, poorly designed content will indefinitely cause a product to fail. Similarly, poorly designed graphics are also detrimental. This paper presents several of the theoretical and technical aspects of creating exceptional computer graphics for multimedia and hypermedia projects. (*Keyword: multimedia, hypermedia, raster graphics, design*)

INTRODUCTION

PROPORTIONAL TO THE COMPLEXITY of our communications media, the range of skills required to create interactive multimedia media (IMM) and hypermedia (HM) products is quickly becoming more diverse. Today, authored programs are capable of including a wide variety of media elements. From text and graphics to sound and video, almost any combination of these media elements can be used in today's CD-ROM, Web, or hybrid communications tools.

Yet, the development of each type of media element requires a specific skill set and usually has a sufficient amount of research data concerning its use. Therefore, in IMM and HM development, where

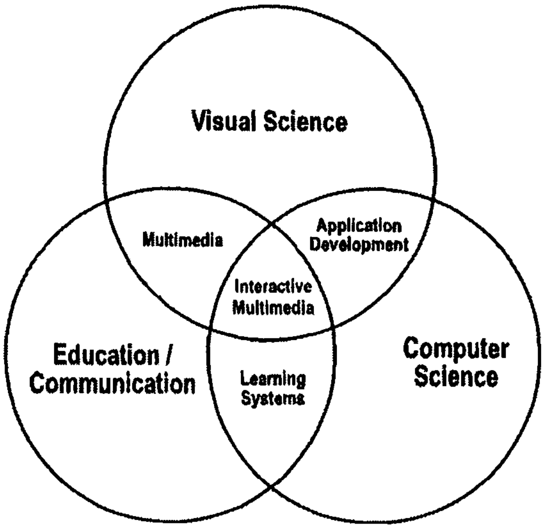

Figure 1. The knowledge bases involved with interactive multimedia and hypermedia creation

any range of these media elements can be involved, the number of people required to create a communication tool can become quite significant.

However, at some base level, the entire IMM and HM knowledge base can be summarized by the three component knowledge areas that are involved: education/communication, visual science, and computer science. Each of these areas significantly impacts the effectiveness of a IMM or HM tool. Often, absence of representation from any area is noticeable in the end-product. Where unsuccessful communication devices are concerned, most are a result of a missing key person in one of these primary areas during the development of the product. IMM and HM development requires interdisciplinary skills.

As shown in Figure 1, the combination of education/communication, visual science, and computer science composes the knowledge base for IMM and HM development, as well as other types of digital communication tools. It is the intersection of these knowledge areas that allows for the creation of communicative tools designed to inform, educate, persuade, or entertain. The intersection of two knowledge areas is what allows a somewhat similar, yet different type of digital creation.

A careful examination of these three areas reveals the significant aspects that they contribute to IMM and HM development. Note that education and communication includes the principles involved in instructional design, effective communication, information architecture and the pedagogical concerns for the transfer of knowledge. Visual science includes the knowledge necessary to create effective graphics, interfaces, and other visually-based media elements. Visual science directs our attention to where graphics should be used and when they are most effective. Computer science covers the knowledge necessary to understand the many hardware and software issues related to development, such as networking, programming, and other computer software concerns. As it relates to Web or hybrid products, the computer scientist understands the implications of the browser, bandwidth, and the effects of client and server on delivery.

As the content is being development, often the person familiar with visual science will need to assist by not only creating the visual content elements, but also suggesting ways in which graphics and other media elements can be effectively used. More often than not, people outside the graphics area have some understanding concerning the use of graphics but usually need assistance in determining applied issues, such as creation methods, placement, size, and the amount of photo realism. The task of the visual specialist is to assist in this area.

THE ROLE OF GRAPHICS

ONE OF THE MOST DIFFICULT THINGS for people out side the graphics arena to do is to determine the most effective places for graphics in CD-ROM or Web-based communication products. Most are aware of the importance of using graphics but feel uncomfortable with making decisions concerning where to use them as well as how to create and implement them. Often a graphics specialist will work with a content specialist to determine the most effective places to insert graphics, as well as the types of graphics to use. By analyzing the content and the audience a graphic is evaluated for appropriateness to a particular communicative purpose. In addition, the visual specialist assists the computer scientist in developing the user interface; the point of interaction for the product. Through the use of concepts, such as clustering, eyeflow, composition and layout, the graphics specialist assists in making the screen designs for the product easier to interpret.

In the application of graphics to any particular IMM or HM purpose, the graphics specialist determines if a graphic will:

Enhance, complement, supplement, or complete content that cannot be adequately described or explained with text. Often graphics are used to supplement or replace certain parts of text-based material. A single well-designed and properly executed graphic can eliminate several paragraphs of text. In most IMM and HM products, the primary use of graphics is for content purposes. Graphics used in this way help to increase attention, motivation, comprehension, and interpretation.

Present items such as buttons, button bars, and icons to allow for navigation. Over the past ten years, computer users have slowly migrated away from command-line interfaces to graphically based ones. Graphically-based interfaces present an easier, more effective, and often, more efficient means of interacting with the computer. Icons, menus, and other graphical constructs can help the end-user in navigating information by presenting a more logical, interpretable, and user-friendly structure for interaction. As many propose, graphics for the navigation of information will become more important as the general society appear to be slowly moving away from glottographic (vocal-based) communication to semasiographic (meaning-based) communication means.

Create a visual flow through the use of directional, helper, and "filler" graphics. Unlike traditional media, such as textbooks, most IMM tools have unique interfaces and unique content structures. Knowing where to look for navigation and content usually requires visual direction of attention within the particular tool. With texts, rules are learned early in life as to the navigation of a book, as well as the rules for reading. Yet, with unique IMM tools, more visual assistance is needed. Therefore, graphics are often used to direct attention, eyeflow, and create a visual construct for interpretation of the interface. Using graphics to direct attention allows one to easily find navigation items and quickly find the content to be assimilated.

Aside from the primary uses of graphics for content, navigation and eyeflow, graphics that are used within IMM and HM should also follow guidelines:

Graphics used for content purposes should always aid in communication. They should always display something that cannot be adequately communicated with text or to add more clarity to the content being presented. Often graphics are used to display visual or spatial relationships, overcome language barriers, add credibility, involve reluctant readers, or aid in interpretation. Graphics can often eliminate the need for lengthy text or audio-based narration.

Graphics should never overshadow or distract the audience from the message you are communicating. Every graphic placed within a product should have purpose. Simply inserting graphics to add flair generally distracts the audience from the message at hand. Too many dancing bullets, animated GIFs, or other active elements are almost always detrimental when used in mass. In addition, static elements, when used in large quantities, can be equally numbing. Graphics used in IMM or HM materials should have purpose: to help the user interpret the content, to help the user navigate the content, or to help the user by directing his or her attention.

Graphics contribute to the overall tone of the product. The tone of a Web site or an interactive CD-ROM is often conveyed by the graphics. Additionally, the evaluation of any given product, even if the content is not significantly graphics-based, is most often derived from the quality and use of graphics. Graphics must be designed around the expectations of the audience and with the communicative goal in mind.

The audience's impression of your graphics is not only based on what is being shown in the graphic, but also on its size, quality, orientation, placement, and processing requirements. Generally the graphically challenged are concerned only with what appears in the graphic. Yet these other attributes significantly contribute to the evaluation of a particular graphical asset. Related to size and quality, especially on the Web, is the proportional file size of a particular graphic. Modem-based Web surfers who encounter a Web page with a large cumulative file size will likely cancel the download if it takes more than a couple of minutes. Understanding the issues related to the use and delivery of graphics is as important as understanding how to create them.

BEGIN WITH THE END IN MIND

ALTHOUGH STEVEN COVEY was the first to coin the phrase "begin with the end in mind," it is important when dealing with graphics for interactive media as well. No matter what type of product you are creating, knowing what you want to create is vitally important. Once you know what you want to create, you can then chart the variables involved with getting from point A to point B.

Depending on the type of graphic, there can be any number of variables with which one must contend. With multimedia graphics, almost all are bitmaps due to available bitmap characteristic known as anti-aliasing. Yet, if you know much about graphics at all, you realize that bitmap graphic files, because they are defined pixel by pixel, can become quite large. Undoubtedly, the biggest hurdle then is to design bitmaps so that they display qualitatively for the audience without a tremendous digital file size. Note, however, that the quality level needed is somewhat arbitrary and depends solely on the expectations of the audience.

In general, there are three attributes that affect the file size, and therefore the image quality, of any bitmap graphic: image resolution, image size, and image bit depth. When developing for the Web, optimally, graphics should be designed so that the audience can view them without waiting for long periods of download time. With CD development, graphics should be designed so that they can be easily imported into an authoring program, as well as loaded from a CD at run-time. Note that adjusting any of the three bitmap variables (resolution, size, or bit depth) can greatly affect the quality and file size of an image. If, for example, one of the variables is set too low, there will be too little data contained in the graphic file and the aesthetic results of the image can be impaired. In contrast, if one of the bitmap attributes is set too high, image quality may be astounding, yet the file size makes the image of little use.

IMAGE RESOLUTION

The first attribute of concern is resolution which is often called dots per inch (dpi). To be technically accurate, when dealing with display output, this is generally called pixels per inch (ppi). Realize that dpi equals ppi and that the terms are used interchangeably with graphics and desktop publishing output. Dpi or ppi is a measurement used to describe the number of physical dots per square inch of the image. It can also be used to describe the quality of a device. With image resolution, the required dpi is dependent upon the output device. For most multimedia development purposes, where a computer monitor is the only output device, 72 dpi is all that is needed because 72 dpi is the maximum resolution of all computer monitors. Using higher dpi settings only adds extraneous and unneeded data to multimedia graphics.

IMAGE SIZE

The second image attribute, image size, is directly related to resolution. Image size is the physical height and width measurements of any bitmap image. Realize that there is a fixed relationship between the image size and the image resolution. Thus, bitmap images are called device dependent, meaning the dpi cannot change without a change in image size. Due to the device dependency of raster images, image sizes must be known prior to creating any bitmap graphic so that a minimum dpi of 72 may be maintained.

IMAGE BIT DEPTH

The last attribute of bitmap images is bit depth. Understand that bit depth concerns much more than just bitmap graphics in multimedia. It is also relevant to digital video and audio as well. In general, bit depth defines the descriptiveness (quality) of any graphic, video or audio clip. With graphics, bit depth affects the number of colors that can be used in an image. With audio, bit depth affects the number of decibels that can be used within an audio clip (note that decibels does not necessarily mean "loudness").

To fully understand bit depth and its relationship to bit map graphics, one must understand the underlying principles of analog and digital data. Much of what the computer does revolves around the conversion between analog data—that humans can interpret—and digital data—that the computer can interpret. Computing is not just processing data. It is also managing the digital-to-analog and analog-to-digital conversion process. Whenever a graphic, audio, or video clip is created using a scanner, a stereo, or a VTR, a process known as sampling must occur. The device converts analog data to digital data so that it can be used within the computer.

For example, digitizing audio into the computer requires sampling the audio (converting it from an analog source, such as a tape recorder, to a digital file on the computer). The sampling process requires taking small chunks of that data, at specific intervals, and converting it, so as to digitally represent the analog data (see Figure 2). The more frequent the chunks or samples, the more the digital audio is like its analog counterpart. The frequency, or how often those samples is taken is called the sampling rate. The higher the sampling rate, the more accurate the finished audio clip because more frequent samples of the analog source are taken. Note that when scanning a graphic, a higher sampling rate allows for a larger image or a higher dpi.

Once an analog sample has been taken, the computer must then digitally describe the sample. Describing the sample is how bit depth relates to graphics, audio, and video. Bit depth defines the number of physical computer bits that can be used to describe the sample. The more available bits for the digital description, the more representative that sample is.

As it relates to bitmap images, bit depth controls the number of colors that can be used to describe any bitmap graphic. In multimedia work, most images are 24-bit or 8-bit images. These measurements describe the number of bits that can used to represent the image. In a 24-bit (true color) image, each pixel in the image can be any one of 16.7 million colors or 2^{16}. In an 8-bit (indexed) image, each color can be any one of 256 colors or 2^8. Notice that a 24-bit image allows for a better representation of an image because it has more bits (colors) with which to describe the samples (pixels) in the image. True color images also allow special data—layering, masking, and other information—to be included within a digital file.

DESIGN CONSTRAINTS

Throughout the previous explanation, it is assumed that the sampling process is being used to create digital graphics or other media elements. When the developer desires to create graphics from scratch

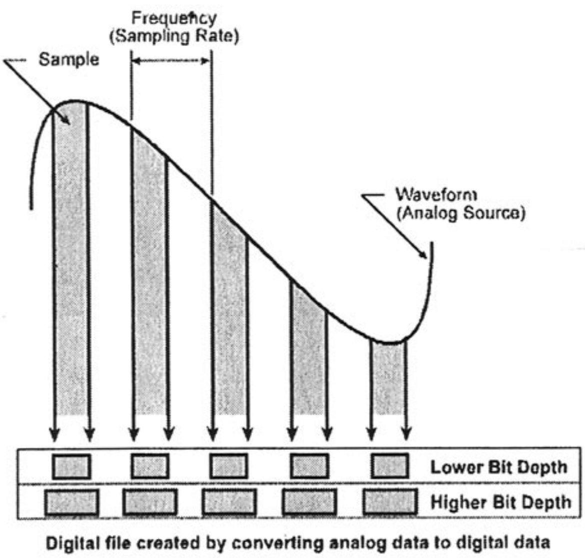

Figure 2. The sampling process and its relationship to image bit depth

using a paint program, the bitmap variables are set in the beginning of the creation process. Using a application such as PhotoShop to open a new drawing allows the user to choose and set the size, dpi, and the bit depth upon starting the new drawing. Because the quality of bitmap graphics cannot be improved once the variables are established (unless the image is truly resampled), it is important to know what settings are needed before beginning the creation of a bitmap graphic.

Aside from a general understand of bitmap attributes, beginning developers should remember that:

There is a fixed relationship between the image resolution and the image size of a bitmap, which results in device dependency. Increasing the size decreases the dpi, causes interpolation, and results in a blurry image. Reducing the size of an image, increases the image dpi, causes data to be deleted, and sharpens the overall image (when displayed at true size).

When designed for display output only, all images for IMM or HM products should be a maximum of 72 dpi. Using dpi (or ppi) settings greater than 72 only adds unneeded data to graphic images, which wastes bandwidth on the Web or hinders data transfer from a CD. However, when sizing images, you must insure that a dpi of 72 is maintained when the image is displayed true size, so that noticeable pixelization does not occur.

Akin to dpi, bit depth also affects the quality of the image. With a higher bit depth, more colors can be used in the image resulting in a higher quality image. A lower bit depth results in fewer colors and, consequently, a lower quality image. You must establish the color depth of the target audience before you sample or create graphic images. Attempting to increase the color depth on a lower-depth image will gain no visual clarity or quality (although the file will get bigger nonetheless)!

Each 8-bit image has a Color Lookup Table (CLUT), also called a palette. All the pixels in a 256-color image are assigned a color from the palette. In CD-ROM titles that are designed for 256 colors, all images should use a single color palette. If a wide range of colors is needed, the Macintosh or Windows system palettes will usually be adequate.

The palette for any given image may be changed by mapping the image to a new color palette. When remapping colors, imaging programs do their best to match the existing colors to ones in the new palette through various types of dithering styles. However, if the new palette contains too few related colors, some banding or color shifting may occur. Nonetheless, all color remapping should be performed with in an image editor, rather than relying upon an authoring program or browser to do it. Authoring programs, as well as browsers, do a poor job of dithering colors and often dither inconsistently across platforms.

Be aware of browser safe color palettes and how they can aid you in designing around the 8-bit display environment. Keep in mind that the most common 8-bit display problem (banding or shifting) will occur with graphics that have large flat color areas. This is where a browser-safe color palette is most effective. Photographic images are seldom helped by the browser-safe color palette.

Image resolution, image size, and image bit depth all affect the size of the digital file. Increasing or decreasing one of these attributes increases or decreases the size of the file respectfully. In IMM and HM development, you must always strive to work with the highest quality elements until the point at which you insert the file into an authoring program or Web page. Sample high and then down-sample (decrease size or color depth) for distribution.

Always maintain a high quality version of graphics for future editing, even if they are being distributed on the Web at lower resolutions. Realize that you may decide in the future that you want to reuse a graphic. Decreasing size, dpi, or bit depth deletes data from the file. This deleted data (reduction in quality) cannot be regained unless it is resampled or recreated. Often developers will maintain both 8-bit and 24-bit versions of their graphics at true size—true size being the proper height and width (at 72 dpi) needed within the Web page or authoring program.

UNDERSTANDING THE JIGSAW PRINCIPLE

ASIDE FROM THE BASICS OF RASTER GRAPHICS, three other areas seem to be of particular trouble to newcomers in digital graphics, IMM, and HM development. These include the jigsaw principle, raster layering, and raster graphics file formats.

The jigsaw principle is a fundamental construct that is used in both the CD-ROM and Web media. By dividing bitmap graphics into individual segments, certain parts can be assigned certain functions. For example, the graphic shown in Figure 3 looks as if it is composed of a single large image. Yet in reality, it is divided into separate pieces and imported into the authoring program as a series of images.

By using the jigsaw principle with IMM graphics, each graphic can be assigned to perform a specific task because each is actually a separate and discrete object. Commonly, buttons, button bars, and other interface elements are designed as a set of graphics that are assembled in the authoring program. Each piece may be assigned to a different operation or task. Contrasting Figure 3 and Figure 4 reveals how an image can be divided up prior to importing it into an authoring program.

Aside from its implications in IMM, the jigsaw principle is becoming more widely used on the Web as well. As a means to sidestep image maps, many sites use a series of images, formatted within a table, to give the appearance of a singular image. Once a design is generated within an image editor, the image is divided into several pieces and then integrated into a Web page. The graphic shown in Figure 5 shows an example of a Web page that uses several puzzle pieces, a table, a background tile, and several "glass bricks" to create the completed design, rather than a large image map. This technique often yields shorter download times and the appearance that the page has loaded faster.

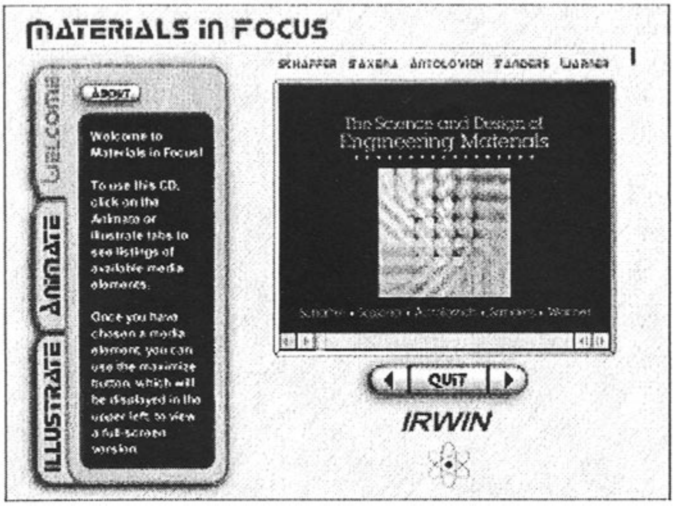

Figure 3. Although it looks like a single image, the picture is actually composed of several pieces that are put together to create the illusion of a single graphical user interface.

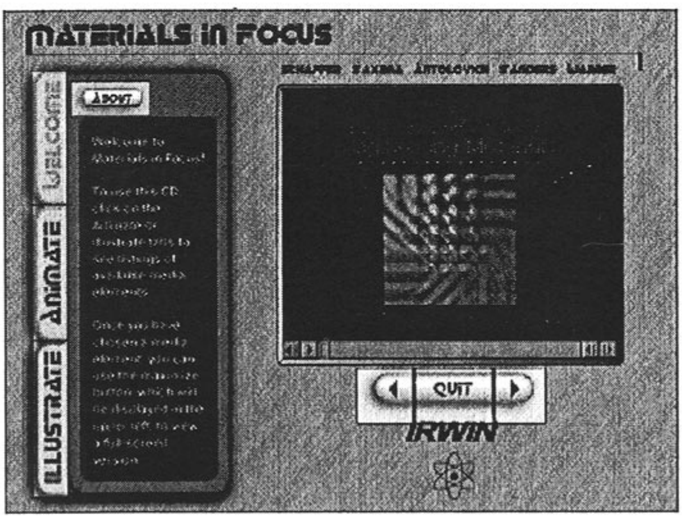

Figure 4. By outlining the various pieces of the puzzle it becomes more obvious how the image is divided up.

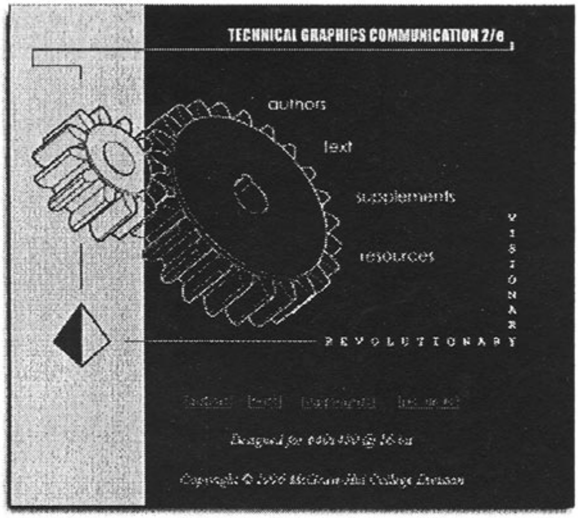

Figure 5. Several bitmaps can be assembled using a table and a glass brick rather than a large image.

AVOIDING DESIGN FLATLAND

MOST OF TODAY'S BITMAP EDITORS ENABLE the developer to overcome the biggest problem of raster image editing in the past: imaging flatland. In times past, the graphics specialist worked on a single layer. In this type of environment, anything that was selected, painted, or pasted in, removed anything that was behind it (see Figure 6). This meant that the developer had to get it right the first time. Single layer raster environments are inflexible and often hinder creativity.

Yet today, imaging packages, such as PhotoShop, include layering capability. As in any package, using layers is like drawing on clear acetate sheets. Visual information (pixel data) is inserted onto a transparent layer. Much like cel animation, the combination of layers creates the final composited image as shown in Figure 7. Layers can be turned off and on as well as rearranged or deleted. Special compositing effects can also be used to achieve that definitive look.

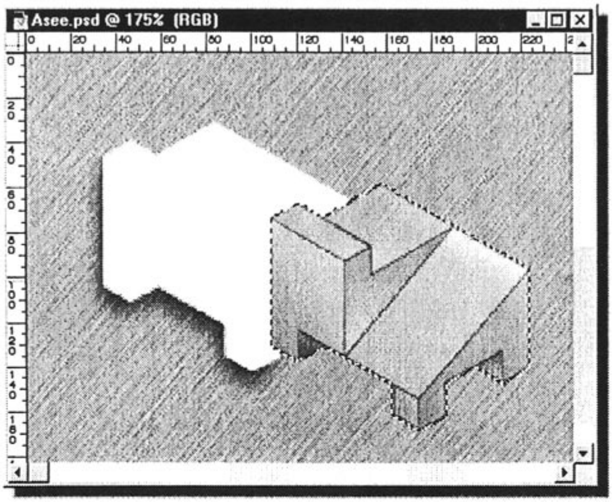

Figure 6. Pasting or painting pixels in a single layer environment deletes background pixels.

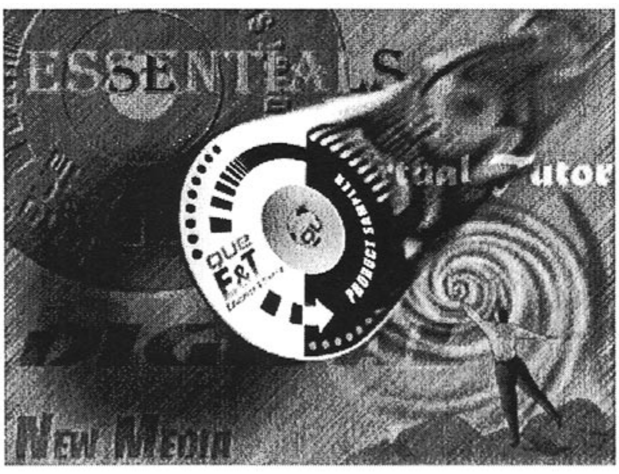

Figure 7. Using layers in a raster environment allows the developer to create complex effects very easily.

Layering adds a third dimension to raster illustration, making the illustration easier to work with as well as easier to edit.

Layers in the raster environment help the developer in many ways. Layers provide a fluid means of designing IMM or Web interfaces, buttons, and icons. As artists or illustrators, much of what is created is discovered through experimentation. Many times, through trial and error, the effect a developer is looking for is discovered through multiple iterations of an illustration. Seldom does the end-user understand the number of interations or alterations needed to generate the final product. In addition, layers make other operations—masking, compositing, hue, light, or saturation adjustments—easier. In a single layer environment these types of changes are somewhat difficult and time-consuming to execute. Yet, as some would argue, in the single layer environment these types of changes are not impossible. They are just inefficient compared to other methods. Realize that every extra minute that is spent on the raster graphic, or any other part of an IMM or HM product, decreases the profit margin.

GRAPHIC FILE FORMATS

THE NEGATIVE SIDE of using layers, as well as other advanced features, is the amount of extraneous data added to the digital files. File sizes increase dramatically as the number of layers increase. It is not unusual for a layered PhotoShop file to exceed 8 megabytes, which not only requires more file space but can also significantly increase display and editing calculations.

In addition to the basics described concerning bitmap attributes and the layered environment, developers must also be aware of file format issues. Understanding raster file formats and how they differ, requires a knowledge of what the files actually contain. Much of this is related to the image's bit depth.

Raster image files predominantly store pixel data. However, many of the 24-bit (or higher) file formats allow more than just pixel data.

In PhotoShop, files that contain layers, paths, or channels can only be saved in PhotoShop's native format (.PSD). Images that contain only (alpha) channels—saved selections—can be saved in Tagged Image File Format (.TIF). As you are probably aware, the Graphic Interchange Format (.GIF), which is the predominant format for the Web, can only contain 8-bit image data.

CONCLUSION

AS IMM AND HM DEVELOPMENT CONTINUES TO EVOLVE new tools will undoubtedly emerge. Yet, as long as computing is based upon binary arithmetic, the basic bitmap attributes will remain unchanged. Most of the frustration individuals have with computer graphics are due to a lack of understanding concerning the primary bitmap attributes. In addition, concepts such as the jigsaw principle and raster layering also cause confusion. The focus of this paper has been to describe and define the basic raster graphic fundamentals to aid new developers in understanding the essentials of raster graphics and their application to IMM and HM development.

REFERENCES

Burger, J. (1993). *The desktop multimedia bible.* **New York: McGraw-Hill.**

Hamlin, J. (1996). *Interface design with PhotoShop.* **Indianapolis: Macmillan Computer Publishing.**

Horton, W. (1991). *Illustrating computer documentation.* **New York: Wiley.**

Lindstrom, R.L. (1994). *The business week guide to multimedia presentations: Create dynamic presentations that inspire.* **New York: McGraw-Hill.**

Mohler, J. (1997). *Graphics, animation, and multimedia, volume VII of the Web publishing and programming resource library.* **Indianapolis: Macmillan Computer Publishing.**

Mohler, J. (1997). *Teach yourself how to become a webmaster in 14 days.* **Indianapolis: Macmillan Computer Publishing.**

Vaughn, T. 1993). *Multimedia: making it work.* New York: **McGraw-Hill.**

Wolfgram, D.E. (1994). *Creating multimedia presentations.* **Indianapolis: Que.**

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