Computer Science

COMPSCI 111 S2 C - Lecture 6
July 2003

Bitmap and Vector Graphics
(Introduction to Painting and Drawing applications)

Vector Graphics

After computers had graduated from punch cards to computer screens, people tried to use computers to represent information graphically. Unfortunately, the screens which computers used were text-only, and did not have the capacity for computer graphics. However, it was possible to write a program which sent instructions to a peripheral device (such as a plotter) which would draw the output in a graphical manner. These devices controlled a pen which it could move up, down, left, right, forwards and backwards. Because each part of the drawing was a line segment, the information about the lines was stored as mathematical vectors. Devices which used this technique became known as Vector Graphics Devices. The vector graphics screen became commonplace for displaying early computer graphics of this type. This screen was a cathode ray tube, which shot an electron beam onto a phosphorus surface. The electron gun would trace each line (or vector) in the object about 60 times per second. This technique produced excellent results for Computer Aided Design (technical drawings), and is still in use today, albeit uncommonly.

Object:	
Name:	Circle
Attributes:	
Radius:	5
X Position:	120
Y Position:	231
Pen Width:	3
Pen Colour:	Black
Fill Colour:	Green

Figure 1: Information about objects is stored as independent attributes.

Some graphics applications use the vector graphics paradigm to represent the objects to be drawn. Using this representation, each object is stored independently. A list of objects is created, with each object specifying its location, line width, colour, orientation, and other attributes. The primary limitation with this method is that only shapes that can be easily described in mathematical terms (such as square, rectangle, circle, ellipse, polygon, line) can be represented. There are many advantages to storing graphics information in this manner:

• Since each object records attributes describing the way it looks, it is possible to alter any of these attributes in order to alter the appearance of the object. This can be done even after the object is created. Each object is able to be manipulated independently of the others.

• Given the information stored in this way, it is possible to scale the image and retain the desired look… just change the size attribute of each object (eg; try this in ClarisWorks Drawing).

• It is possible to describe the shape of letters (characters) using lines and curves, so entire fonts can be created which use vector-based descriptions of the characters. Note that TrueType fonts are stored in this way to enable them to be scaled effectively.

• Most printers today are compatible with the Postscript language developed in Xerox PARC. This language operates via a vector graphics paradigm, using mathematical formulae to describe smooth curves. A graphics program (like a drawing package) which stores information using vector graphics is able to convert the information to Postscript, and so the printed lines will look smooth and professional.
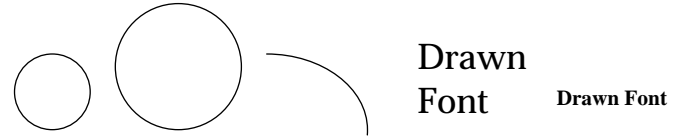
Drawn Font   **Drawn Font**

Figure 2: Objects Stored using the Vector Graphics Paradigm scale smoothly, and can be printed by postscript using the original attributes of the object.

Raster Graphics

Raster Graphics devices developed with the idea that a picture could be formed from a very small grid of dots. The first common technology to use this idea was the television. A cathode ray tube is used, but the electron gun does not scan each object like a vector graphics device, but rather scans horizontally across each row on the screen, regardless of what is actually being drawn. The rate of refresh (i.e. how many times the screen is redrawn) needs to be about 50 times a second (50Hz) to avoid flickering. Modern computer screens use this Raster Graphics technology.

A picture stored using the raster paradigm is known as a Bitmap. Historically, pictures consisted of black and white dots only. This meant that each dot of a picture (pixel) could be stored using a single bit. The contents of the bits in memory mapped onto the screen image, and were hence known as a bitmap. Today, most bitmaps use many colours which means the mapping between memory and screen is no longer 1 to 1, but often 8 or 16 to 1 (i.e. sixteen bits are used to represent each pixel).
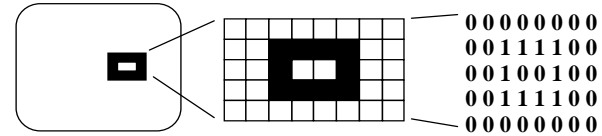


```
0 0 0 0 0 0 0 0
0 0 1 1 1 1 0 0
0 0 1 0 0 1 0 0
0 0 1 1 1 1 0 0
0 0 0 0 0 0 0 0
```

Figure 3: Bits in memory map onto the screen representation in a 1 to 1 relation.

Early printers that used the raster graphics paradigm were known as dot-matrix printers, and were available in a number of different varieties. The more dots that you were able to fit into a small area, the smoother, and more realistic the images would appear when printed. Newspapers and many magazines still use this approach to printing pictures. If you look closely, you are able to see each individual dot which makes up the picture.

Representing graphics information using a bitmap has its disadvantages:

• Because the original picture information is stored in a discrete grid, the only way to increase the size of the image is to increase the size of each dot. The image will then begin to appear to be of poor quality as jagged edges become more apparent.

Painted Font

Figure 4: Objects stored using a Bitmap do not scale well.

• Laser quality printers use Postscript, which is a vector based language. Each dot in the bitmap image is converted into a small square (or circle), and printed out as a dot by the printer. An average laser printer is capable of printing with a resolution of about 600 dots per inch, whereas a screen is typically 72 dots per inch. The capacity of the printer is usually wasted when printing bitmap images. In order to use it to get am image as crisp and clear as possible, the bitmap on the screen needs to be 10 times as large as the final printing will appear, that way a 1 to 1 mapping can occur between the printer resolution and the screen resolution.
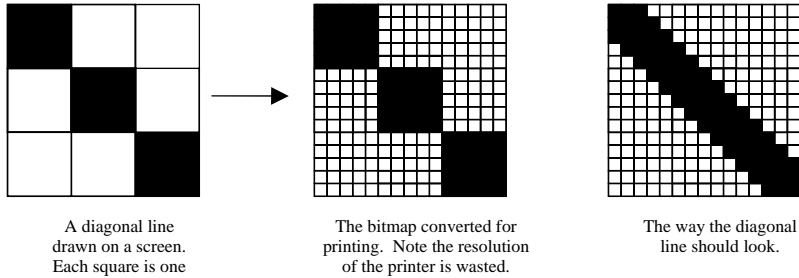
A diagonal line drawn on a screen. Each square is one

The bitmap converted for printing. Note the resolution of the printer is wasted.

The way the diagonal line should look.

Figure 5: Printer Resolution exceeds screen resolution, causing difficulty for graphics stored as bitmaps.

Why would you want to use bitmaps at all? Consider how a photographic image would be stored. Vector graphics is only capable of representing a small number of mathematical shapes, so it is simply incapable of representing the complexity involved in a photograph. The closest it would be capable of would be to divide the object up into a large number of regular shapes, where each shape contained a uniform colour. But that is exactly what a bitmap is… so it would be more efficient to store the image as a bitmap!

Vector graphics is more efficient when the image to be represented consists of regular shapes. Bitmaps should be used when the image is more complex, with irregular shapes.

Using Painting and Drawing Applications

You create drawings from objects. Drawing is like making a collage. You arrange and layer separate pieces. Painting is like creating a watercolour. You create paintings from images made up of single dots on the screen called pixels. You add and blend colours and textures into a single canvas.

Use Drawing in order to
- Create independent lines and shapes
- Quickly select objects and groups of objects.
- Alter pen and fill attributes after objects are drawn
- Overlap objects and move them to the front or back of the drawing

Use Painting in order to
- Creating images of custom shapes and textures
- Edit precisely by working with one pixel at a time
- Add special effects such as perspective and distortion to images
- Blend, combine and tint images of different colours and patterns.

Drawing Applications

Use a draw document to draw and combine objects, such as lines or circles, that you can select, move, modify, and delete independently of each other. For example, you can use a drawing application to create:
- illustrations, designs, and logos
- brochures
- newsletters
- organisation charts
- slide presentations
- diagrams and maps

Drawing Tools

The tools for drawing objects are usually found in a toolbar, or tool panel. Use the drawing tools to create and edit objects. The drawing tools are usually pre-set to draw solid black lines. Objects drawn usually

have a white fill colour (i.e. white is the default). To draw an object: Click a tool and drag the crosshair pointer in the drawing area. Release the mouse button when the object is the size you want.

Selecting Objects

Before you can move, modify, or delete any object you must select it. A selected object displays handles (small black boxes). An object remains selected until you deselect it or select another object. You select objects with the arrow pointer. If the pointer is not an arrow, click the arrow pointer in the tool panel. To select a single object, simply click on it. To select multiple objects use one of the following methods:

I. Starting outside the objects, drag the pointer across the objects to enclose them in a selection rectangle. Only those objects entirely enclosed are selected.

II. Hold down the Shift key and click each object you wish to be selected.

Attributes of objects

Every object has many attributes which describe what it looks like. The attributes which are used to describe the objects depend upon the application. Most applications use at least the following:

- Location of the object on the page (co-ordinates)
- Object Size
- Width of the outline (pen width)
- Colour of the outline (pen colour)
- Pattern of the outline (pen pattern)
- Colour used inside the object (fill colour)
- Pattern used inside the object (fill pattern)

Painting Applications

Use a painting application (or bitmap editor) when you want to create a variety of artwork and illustrations. The images are created by blending colours directly upon the canvas. There is no notion of objects, merely the colour of each point (pixel) in the picture.

For example, you can use a bitmap editor to:

- create logos for stationery
- draw illustrations for reports or newsletters
- paint abstract images
- create school artwork

Painting Tools

You can use various painting tools to create and edit images. When you're working in application that allows you to edit the bitmap, remember that you are directly making changes to individual dots on a page.

If you want to select a piece of the canvas (for moving or modification) then you need to define the boundaries of the selection before it can be altered. You should use one of the image selection tools to select areas in a painting document.

Most painting tools are similar to those used in drawing applications. Similar attributes can be set for each painting tool before it is used to paint onto the canvas. However, because of the way the information is stored, the attributes of an object may not be altered once it has been painted (since the computer does not distinguish between different objects in a painting canvas).

Author: Andrew Luxton