Vector Graphics

Digital Multimedia, 3rd edition

Chapter 3

Vector formats

- SVG (Scalable Vector Graphics)
  - W3C standard, starting to be widely used, and gaining popularity fast
- SWF (Flash) 

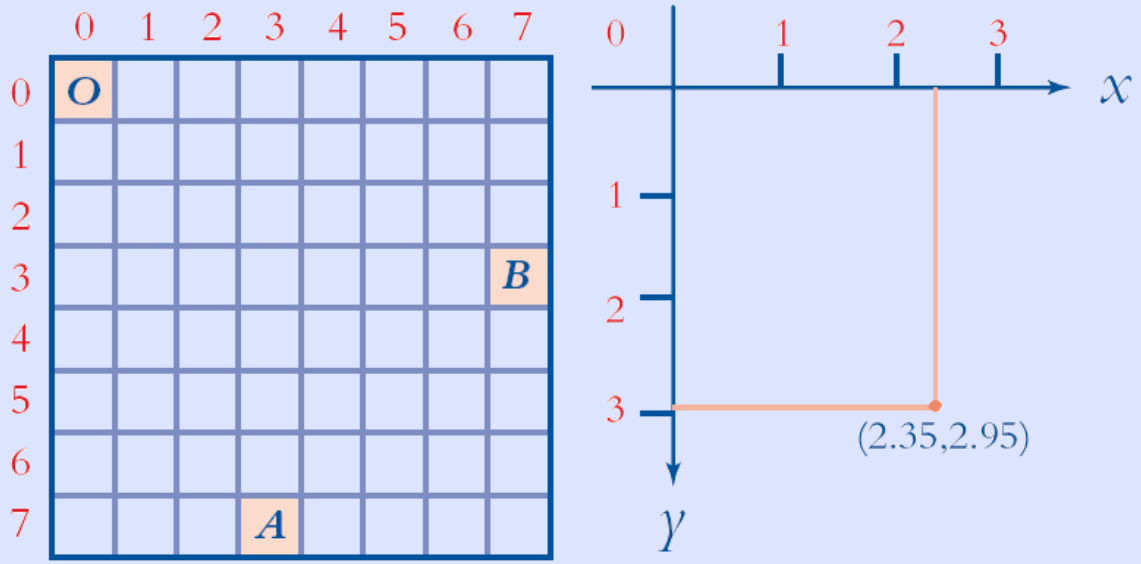
  - Primarily for vector animation, but can be used for still vector graphics
- PDF (Portable Document Format)
  - Mostly used for text documents, but supports vector graphics
    - Adobe Illustrator .ai files are basically PDF files

Vector graphics

- Characteristics:
  - Compact
  - Scalable
  - Resolution-independent

Coordinates

- Each pixel in a rectangular array can be identified by its pixel coordinates (r,c) as whole numbers
  - Whereas in a two-dimensional coordinate space points can be identified by coordinates (x,y) as real numbers

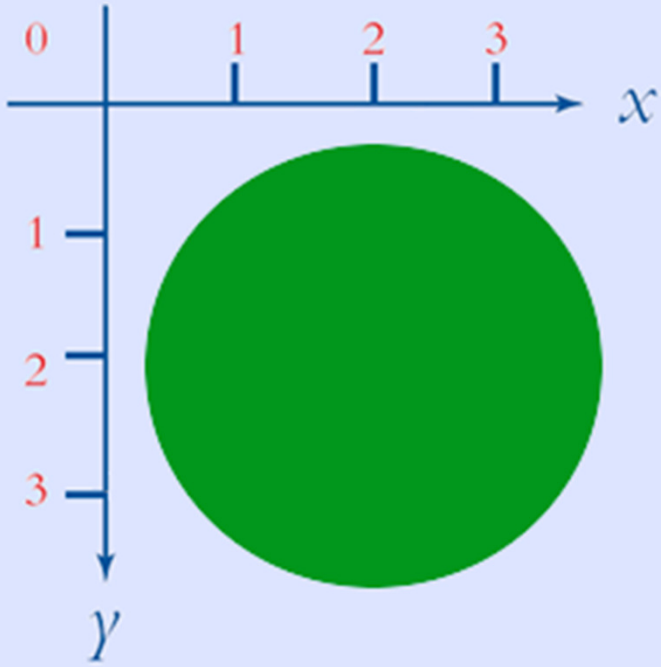


Vector graphics

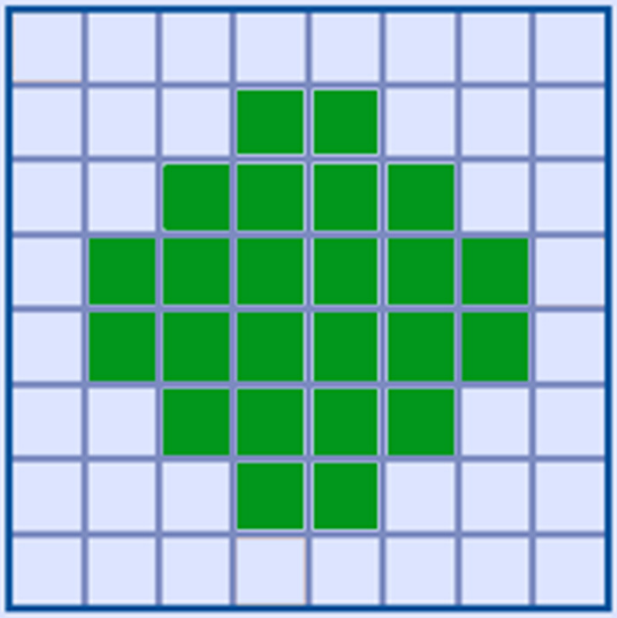
- Lines, curves, and other mathematical shapes can be represented by the parameters of their defining equations
  - E.g. for a line: $y = ax + b$
    - Store the two endpoints of the line; a and b can be calculated
  - Or for a circle: $(x-a)^2+(y-b)^2=r^2$
    - Store the center (a,b) and radius (r)
- Rendered by calculating the pixels which must be set in order to draw the lines, circles, rectangles, etc.

Aliasing

- Rendering is limited to the physical pixels of the output device, so despite being modeled in real numbers, some aliasing might be seen



Model



Rendered

Anti-aliasing

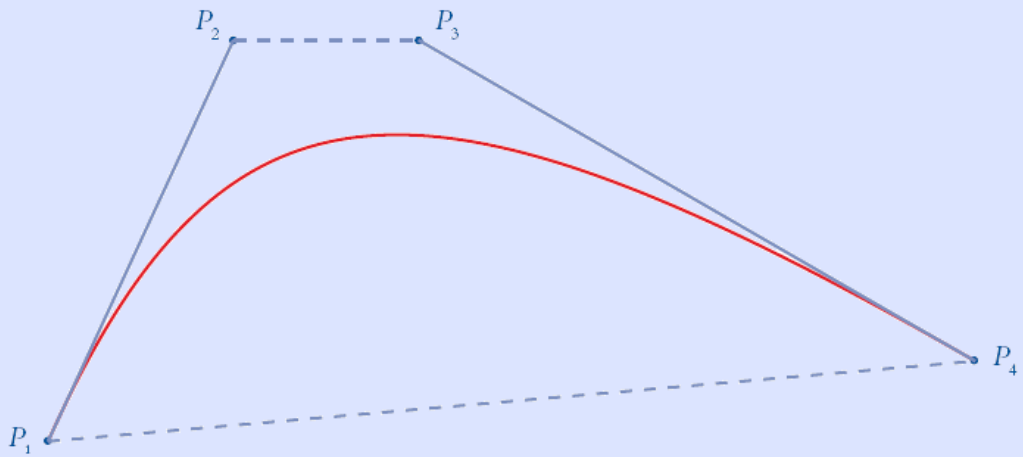
- Aliasing can be reduced (actually only made less visible) by a technique called anti-aliasing
  - Jagged edges can be smoothed out, by adding extra colored pixels, softening the transition between colors
  - E.g. for a black line on a white background pixels of lighter and lighter shades of grey are added

Shapes

- Vector drawing programs (and vector graphics languages) provide a basic set of shapes that can easily be represented mathematically
  - Rectangles and squares (with or without rounded corners)
  - Ellipses and circles
  - Straight lines
  - Polylines and polygons
  - Smooth (Bézier) curves
  - Paths

Bézier curves

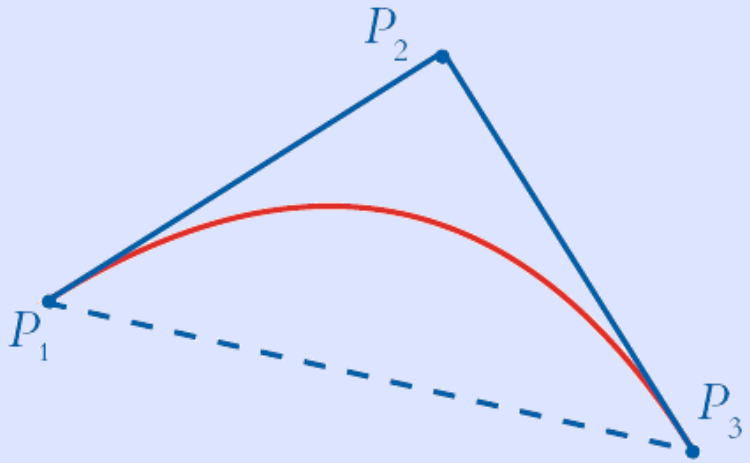
- Smooth curves specified by a set of control points (most often four - cubic Bézier curves)
  - *2 endpoints (P1, P4) - 2 direction points (P2, P3)*
- Shape of curve is determined by the length and direction of lines from endpoints to direction points



Cubic Bézier curve

Quadratic Bézier curves

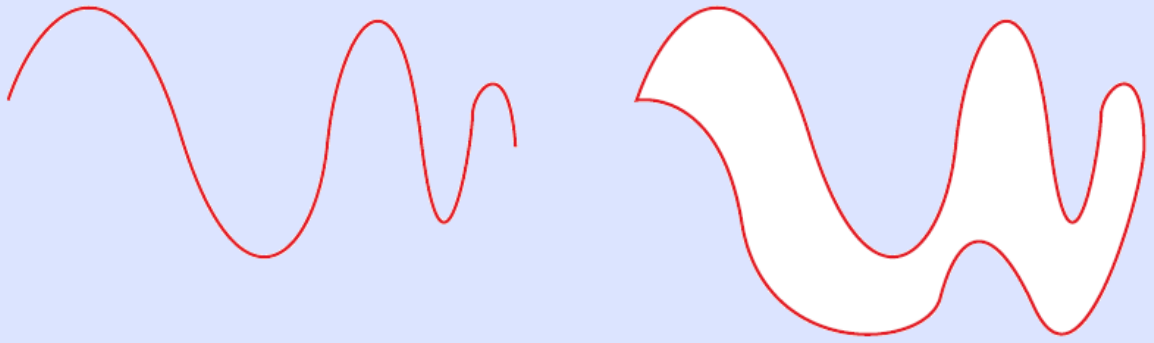
- Quadratic Bézier curves only have a single direction point
  - The only type of Bézier curves supported by SWF
  - PDF and SVG provide both cubic and quadratic Bézier curves



Quadratic Bézier curve

Paths

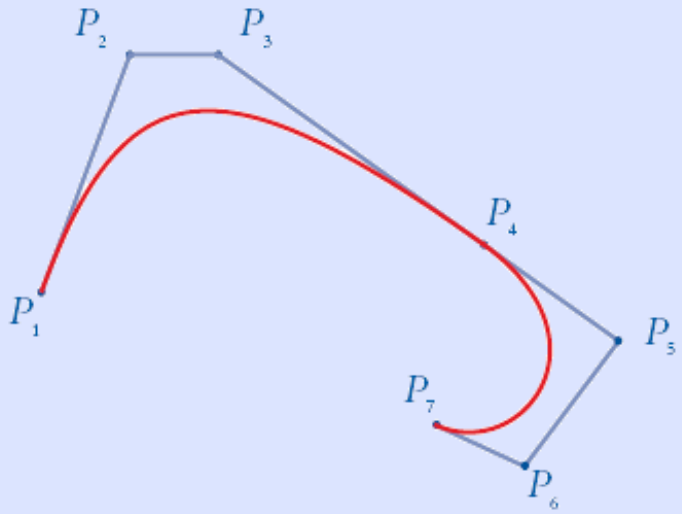
- Paths are sets of drawing instructions for making elaborate shapes containing straight lines, curves, etc.
  - Multiple Bézier curves can be combined to make smooth paths
- Closed path joins up on itself, open path doesn't
- Pen tool in vector drawing programs create paths to mimic our drawings



Open path Closed path

Paths

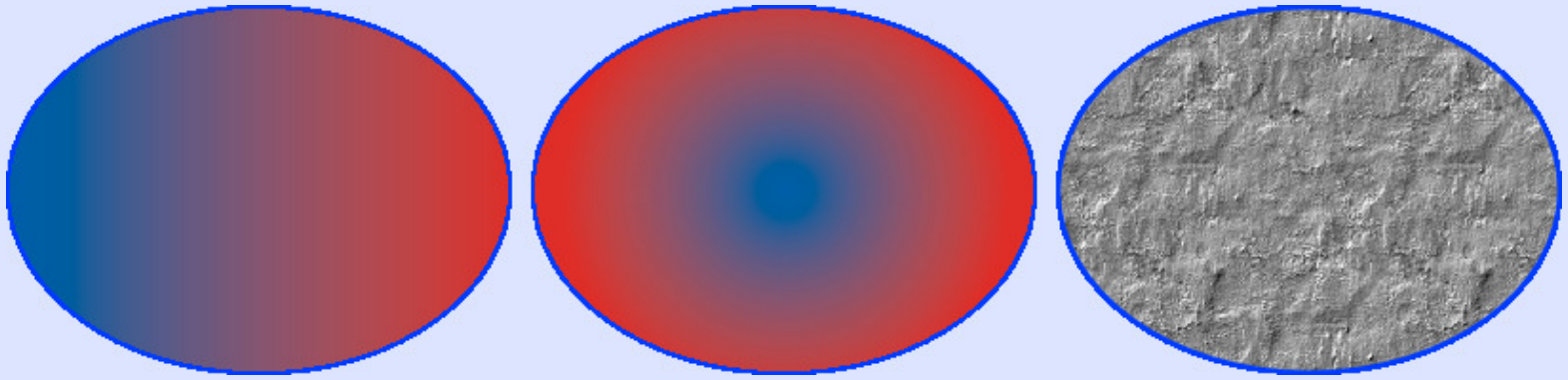
- If two curves join at a point and their direction lines through that point form a single line, the join will be smooth



Smooth join

Stroke & fill

- Apply stroke to make path visible (or to show the outline of other shapes)
  - Specify width, color, etc. of stroke
- Apply fill to path or shape to “color it in”
  - Specify color, a gradient (linear, radial) or pattern



Linear gradient Radial gradient Pattern

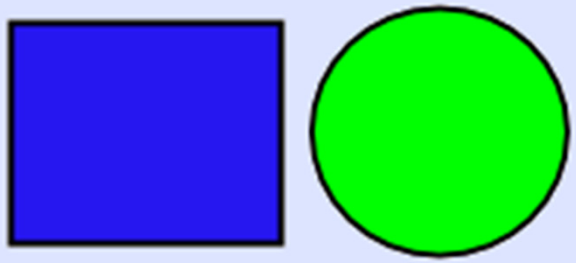
Transformations

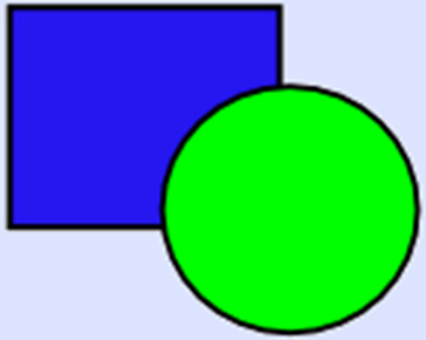
- Manipulate vector objects in certain ways by changing the stored values that describe them
  - Translation (linear movement)
  - Scaling
  - Rotation
  - Reflection (mirroring)
  - Shearing (skewing)
- Transformations are usually preformed either by direct manipulation (tools) or by entering the numeric values

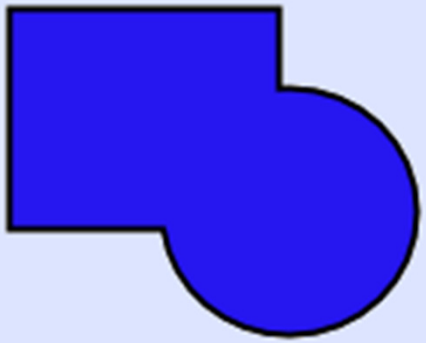
Grouping/joining of objects

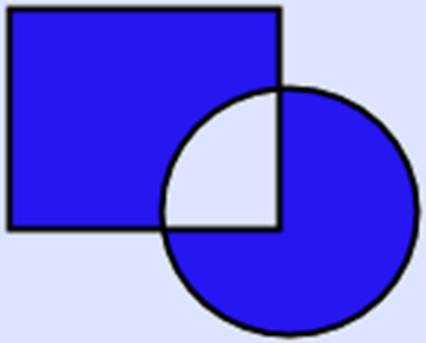
- In most vector drawing programs several objects can be added to groups, and transformed together
- The standard objects can also be joined into more complex objects, using a number of different operations, among others:
  - Union
  - Difference
  - Exclusion
  - Intersection

Joining objects









Union Difference Exclusion Intersection

Vector graphics & bitmaps

- Rasterize vectors
  - Convert vector graphics to bitmap image
- Trace bitmaps
  - Analyze bitmap image and find out which equations can represent it => become vector graphics
    - Difficult and can only produce an approximation - okay for logos etc, not good for detailed images and photos
- Import bitmaps into vector drawing programs
  - Each bitmap is treated as separate objects inside the vector graphics