A graphics file contains data that is rendered to a hardware output.

Recall: Rendering involves processing the graphics data to suit the constraints of the graphics output hardware.

But why do we have so many different types of file?

Examples of Graphics File Formats:
- Bitmap formats
- Vector formats
- Metafile formats
- Scene formats
- Animation formats
- Multimedia formats
- Hypertext and Hypermedia formats
- 3D formats
- VRML formats
- Font formats
- Page Description Language (PDL) formats

Source: “Encyclopaedia of Graphics File Formats” – Murray & van Ryper

How digital images are stored and displayed:
- Display hardware
- Representing shape and geometry
- Modelling shapes – Part I

Labs: Modeling in POV-Ray
Assignment 1: “My first CGSphere” © 2009, Robert McGregor.

Permanent Displays:
- Printers
- Plotters
- 3D Printers

Transient Displays:
- LED monitors
- CRT monitors
- Projectors
- 3D displays
- Stereoscopic
- Holographic
- Light fields
(... Wooden Mirrors?!)

Cathode Ray Tube (CRT) Based on original invention by Karl Ferdinand Braun 1897

Electrons shot from the Cathode are guided by deflectors and hit coloured phosphor molecules exciting them causing them to emit light.
VECTOR DISPLAY DEVICES

- a.k.a. Vector Scan Displays, Random Scan Devices, Line Plotters
- The electron beam directly draws the picture e.g.

\[
\text{DrawLine}(A, B): \quad \text{Turn beam off, move to } A. \\
\text{Turn beam on, move to } B.
\]

COLOUR CRT SYSTEMS

- Phosphors have a specific colour.
- Colour displays systems have groups of 3 different phosphors, for red(R), green(G) and blue(B).
- Combining different intensities of phosphors can generate different colours.
- Each pixel consists of 3 dots of phosphor.
- 3 Electron guns used, for R G and B.
- A shadow mask ensures that each gun can only hit one colour of phosphor.

RASTER SCAN DEVICES

- Scans the screen from top to bottom in a regular pattern (common TV technology).
- Electron beam intensity is turned on/off (for colour: high/low) so the image is a collection of dots painted on screen one row (or scan line) at a time.
- A raster is a row of pixels (picture elements) covering the width of the screen.

OTHER MONITOR AND PROJECTOR TECHNOLOGIES

- Liquid Crystal Displays (LCD) and Thin Film Transistors (TFTs).
- An alternative: Digital Light Projection (DLP) and Digital Micro-mirror device (DMD).

STEREOSCOPIC DISPLAYS

- Depth perception is affected by each eye seeing a slightly different image.

HOLOGRAPHIC DISPLAYS


- Depth perception is affected by each eye seeing a slightly different image.
What is an Image?

- A visual representation that allows us to perceive data.

Describing images:

- High Level: Mood, realism, quality, aesthetics, clarity
- Low Level: Geometry + Colour

Elements of Art: Line, shape, form, space, colour, texture - Getty Museum 2011

Model shape and structure using Geometrical Primitives*

- Add colour to each primitive

Subdivide space into a raster and then assign colours to each pixel

- Don't explicitly store shape
- Geometry is an emergent high-level property of pixels

* primitives = essentially the most basic forms

Geometry: the field of knowledge dealing with spatial relationships or spatial occupancy

Shape, size, position, properties of space, form.

Describing shapes efficiently and unambiguously is difficult enough in everyday life. How do we do this digitally?

- Models should be: Robust, Efficient, Faithful, Digital

Vector object

Raster Image

We may need to compromise a little bit (simplification, abstraction, decomposition, discretization)
Most Digital Images are represented based on certain reusable/recurring digital primitives:

- Raster Images / Sprites
- Text
- Points, Lines, Polylines, Polygons
- Curves

An image made up of many small regularly placed cells called pixels (picture elements)

Stored as an array of numerical values commonly called a pixmap, premap or bitmap

Computer memory is usually one dimensional (or sequential)

Some info is required to get this back to its image form usually a "header" to indicate at least the width and height

The 2D image is unravelled in order to store this in memory

In RGB codes: Blue: 0,0,255 – Red: 255,0,0
Unravelling this leads to a list that’s about 3 times bigger in size...

Add a header to indicate width, height, colour depth? (more on this later)

Traditionally each character was stored as a small raster

Some displays still distinguish between text mode and graphics mode

In graphical systems (e.g. MS Windows), Truetype fonts are stored as curves and vectors – usually smoother to look at in varying resolutions.
10/10/2016

**POINTS AND LINES**

- Points are usually described as vectors \((x, y)\)
- 2 Points make a line segment
- Several line segments make a polyline
- Polylines can be filled and combined to make more complex shapes (in 2D or 3D)

**CURVES**

- Some simple shapes can be fully described by mathematical equations e.g. circles
- For more versatile everyday shapes, we commonly use a family of curves called splines
- Splines are relatively easy to mould into desired shapes

**OVERVIEW**

- What is a model?
- Objective of modeling
- Modeling tools
- An overview of computer model representations

**MODELLING PART 1**

Modelling Shapes

**MODELLING**

Model: an abstract or actual representation of a system or an object.

Models in Computer Graphics deal with data that eventually leads to graphical output (images + animation + video)

**LEVELS OF MODELING**

- **3D Objects**
  - Each stage has its own unique type of data and can accept user input.
  - The more abstract the representation (arguably) the better our opportunities for re-usability and data/computational efficiency.

- **2D Objects**

- **Image**
Objects are usually saved as a raster when you save as a JPG, PNG, BMP and many other raster file formats.

Some vector file formats: SVG, PDF, PS/EPS or if you save in native formats of editors such as Flash, Powerpoint, Paintshop Pro, Illustrator.

Models are usually:
- More abstract
- More compact
- More Reusable
- Easily Modifiable

Models need to be processed (rasterized) before drawing.

Images:
- Low level
- Resolution bound
- Less re-usable
- More limited in how we can change them

Models vs. Images:

Vectors:
The smallest elements of a graphical model

Geometry in computer graphics is most often represented in terms of very basic numerical data:
- Scalars: single values
- Vectors: a couple or triple (or n-tuple) containing scalars -- the number of scalars is the dimensionality.
  - Vectors usually represent direction and magnitude

In Graphics, more complex geometry, e.g. Curves and Surfaces, can also be defined based on scalars and vectors.

Cartesian Coordinates:

Rene Descartes - 1637
Two distances used to denote unique position in 2D

We can also represent a line with two endpoints, each donated by a vector.

Two distances used to denote unique position in 2D

Finally we can denote translation (or change in position) with two values.

“up” = \langle 0, 1 \rangle

“right” = \langle 1, 0 \rangle

North east \langle 1, 1 \rangle

\langle 2, 1 \rangle

\langle 4, 2 \rangle

Same direction different Magnitude

Although used for modelling points, vectors are a lot more general.

They represent
- a direction
- and a magnitude

A point/vertex is actually represented by its displacement from the origin \langle 0,0,0 \rangle.

N.B. Applications sometimes differ on whether z-axis goes in or out of the screen.
The forces of flight.

Mesh Normals

N.B. Different systems have different ranges for the values:
- e.g. 0 to 1: full red is <1, 0, 0>, mid grey is <0.5, 0.5, 0.5>
- 0 to 255: full red is <255, 0, 0>, mid grey is <127, 127, 127>
- 00 to FF: full red is #FF0000, mid grey is #808080

Start with Points/Vertices on the surface of an object
- Defined as displacement vectors <x, y, z> from the origin

Edges are line segments on the surface, defined by pairs of points.

Closed polygons are made up of a number of co-planar edges.

Vectors are used for:
- Position <x, y, z>
- Direction
- Axis
- Colour <red, green, blue>

Also used for other things e.g. velocity, acceleration.

Graphics APIs for 2D/3D programming
- 3D Animation Tools
- Video editors
- 3D Rendering Tools
- 3D Scene Modelling (world modelling)
- 3D Object Modelling Applications
- 2D Painting, sketching curve drawing applications
- Image/photo editors
POV-RAY
The Persistence of Vision Raytracer

POV-RAY IMAGES

"Call of the Wild" © Gilles Tran (2001)


"Distant Shores" © Christoph Gerber (2003)
POV-RAY

The Persistence of Vision Raytracer (POV-Ray) is a free programme for rendering photorealistic images.

Given a 3D scene specified in *.pov format, which is basically plain-text using pov-ray’s scene modelling language, it renders a scene based on fairly complex rendering algorithms.

Input is fairly low-level, although some high-level programmes will create complex models in pov format.

We will be using it to get some quick modelling/rendering done to understand some of the basics components of modelling complex 3d scenes.

http://www.povray.org