

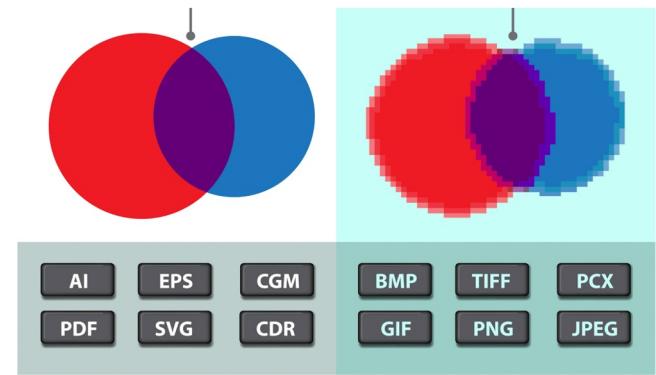
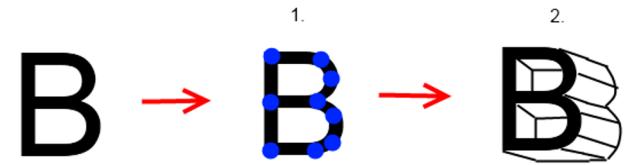
2D graphics, images and audio

CS3005 Digital Media and Games

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CS3005 Coursework

Submission Deadline: 24/11/2021 at 11AM

All questions related to your coursework will be answered in the lab session.

Today's Lab is the last session.

Today's lecture

The learning content for today's session are:

- Text
- 2D Graphics and Images
- Animation
- Audio in games



Text

Text is required for the game:

- To set the scene
- To create dialogue
- To bring the player emotionally
- To give player instructions, tips or feedback

Types:

- Unformatted text (Plain text)
- Formatted text (Rich text)
- Hypertext



The Legend of Zelda

Unformatted Text

- It is the common plain text
- No specialised features to it
- Comprises strings of fixed sized characters:

American Standard Code for Information Interchange (ASCII) (~1960)

- initially 128, then 256 characters to cater for several European languages

Unicode (UTF 1991)

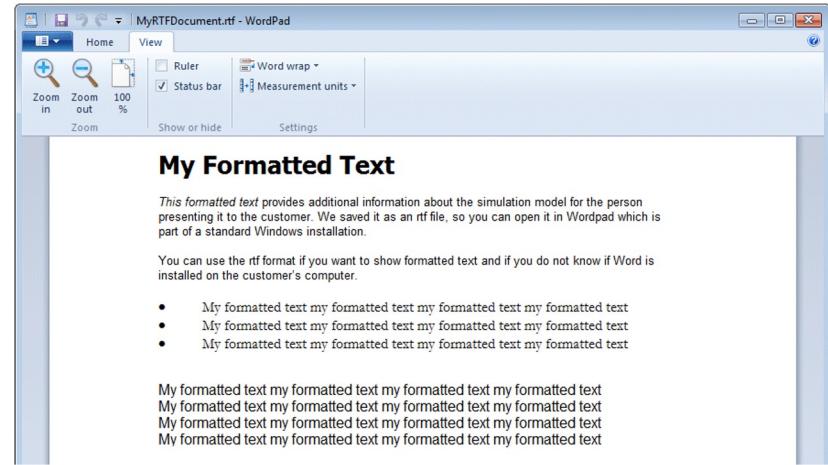
- invented by Xerox and Apple
- to provide uniform character encoding
- covers 96,382 characters using 16-bit

Recipe Collection: Breads and Soups Acom. Soup soup stock pinon nuts 1 Tbsp butter 1/2 c pinon nuts 6 Tbsp chopped onions 7 c chicken stock 1 tsp finely ground black pepper 1 qt milk chopped mint to sprinkle on top Saus pinonuts and onions. Add the stock, salt, and pepper. Bring to a boil, then reduce the heat to medium and cook until reduced by half, about 15 min. Add the milk and simmer gently until the soup is reduced to 5 cups. Blend to a smooth consistency. Garnish with the mint, and serve. Susan Luscious Acom. Soup is easy to make and greatly heating on a winter day. Cream of Squash. Soup soup won squash whipping cream 2 large womb squash 1/4 cup butter 1 c chopped onions 6 c chicken broth 2 tbs lemon zest, grated 2 tbs fresh lemon juice 1/4 cup pepper 1 cup milk Bake the squash. Scoop out the flesh and chop. Save the onion. Add chicken broth and squash; bring to a boil, then simmer 10 min. Add lemon zest, lemon juice, and pepper. Blend until smooth. Return to heat. Add the milk, and heat gently. Alice Fancy Apple Pie dessert pie apple. The Pastry 1 1/2 c flour 1/2 c sugar 1/2 c unsalted butter, cold 1 tbs sugar 3/4 c Tbsp cold water flour (for sprinkling). Make the pie crust in your usual way. Bake 14 min at 400F. The Filling 4 tbs apples, peeled 1 Tbsp lemon juice 2 Tbsp unsalted butter 2/3 c sugar 3 eggs 1 c heavy cream pinch nutmeg pinch cinnamon Grate the apples, save sprinkle with lemon juice to prevent browning. Cook the apples and sugar gently in the butter just to boiling. Simmer until the apples are soft and little liquid remains. Cool. Beat the eggs. Beat in the cream, nutmeg, and cinnamon. Mix in the apples and pour the mixture into the pie shell. Bake until the custard is just set, about 30 min. Adapted from Angela. This is very like some recipes for pumpkin pie. Serves 6 Cardamon Bread yeast bread 2 pkts active dry yeast 1/4 c warm water 2 c warm milk 3/4 c sugar 1/2 c butter 1-1/2 tsp 3/4 c Tbsp ground cardamon 2 eggs 7-8 c all-purpose flour Dissolve yeast in warm water. Add milk, sugar, butter, salt, cardamon, eggs, and 3 c flour. Beat until smooth. Stir in enough remaining flour to form a soft dough ball, and knead. Let rise until doubled. Punch down, divide into halves, shape, and let rise. Bake 350F for 25-30 min. Becky 2 loaves Sweet bread yeast bread 1 c milk 3/4 c butter 1 packet active dry yeast 1/4 c warm water 2 eggs 1 egg, separated 4 c bread flour 3/4 c white sugar 2 tbs lemon zest 1/4 tbs ground mace 1/4 tbs ground nutmeg Scald the milk; add the butter to melt; cool to lukewarm. Dissolve the yeast in warm water and let work. Beat together two eggs with the extra egg yolk. In a separate bowl, combine 4 c flour, sugar, salt, lemon zest, mace, and nutmeg. Beat in the milk, yeast mixture, and beaten eggs. Letrise until double, about 2 hours. Knead in the remaining cup of flour. Divide, shape, and letrise until double. Brush with the remaining egg white. Bake at 325F for 40-45 min. James 2 loaves 20 Calories=238 Total Fat=8 g Cholesterol=15 mg Sodium=87 mg Total Carbs=32.8 g Dietary Fiber=1.9 g Protein=5.3g Saffron Bread 1-1/2 c milk 1 c butter 1 c white sugar 2 1/2 c sifted flour 1/2 c hot water 1/2 c active dry yeast 2 pkts 2 eggs 2 tbs salt 1/2 tbs ground nutmeg 1 tbs ground cinnamon 2 Tbsp grated lemon zest 6 c all-purpose flour Scald milk; add butter and sugar, and let cool. Soak the saffron in hot water. Combine the milk mixture with the saffron water and eggs. Stir in the yeast, salt, nutmeg, cinnamon, lemon zest and 4 c flour. Add the remaining flour slowly, stopping when the dough holds together. Knead and letrise, about 1 hour. Punch down, divide into three, and shape. Bake at 350F a little under an hour. Rye Bread yeast bread 1/4 c cracked rye 1/4 c water 3/4 c milk 1 c water 1 tbs salt 1/4 c brown sugar 1 egg 3 Tbsp butter 4 1/3 c bread flour 4 tbs graham flour 1-3/4 c water dry yeast 1 Tbsp milk Soak the cracked rye flour in 1/4 c water until most of the water has been absorbed. Start the bread in your usual way. Letrise about half an hour. Punch down, form 2 loaves, brush with milk, and bake at 350F about 45min. Adele Thyrie bread uses cracked rye and white flour instead of rye flour.

ASCII control characters		ASCII printable characters		Extended ASCII characters	
00	NULL (Null character)	64	@	96	'
01	SOH (Start of Header)	65	A	97	a
02	STX (Start of Text)	66	B	98	b
03	ETX (End of Text)	67	C	99	c
04	EOT (End of Trans.)	68	D	100	d
05	ENQ (Enquiry)	69	E	101	e
06	ACK (Acknowledgement)	70	F	102	f
07	BEL (Bell)	71	G	103	g
08	BS (Backspace)	72	H	104	h
09	HT (Horizontal Tab)	73	I	105	i
10	LF (Line feed)	74	J	106	j
11	VT (Vertical Tab)	75	K	107	k
12	FF (Form feed)	76	L	108	l
13	CR (Carriage return)	77	M	109	m
14	SO (Shift Out)	78	N	110	n
15	SI (Shift In)	79	O	111	o
16	DLE (Data link escape)	80	P	112	p
17	DC1 (Device control 1)	81	Q	113	q
18	DC2 (Device control 2)	82	R	114	r
19	DC3 (Device control 3)	83	S	115	s
20	DC4 (Device control 4)	84	T	116	t
21	NAK (Negative acknowl.)	85	U	117	u
22	SYN (Synchronous idle)	86	V	118	v
23	ETB (End of trans. block)	87	W	119	w
24	ESC (Escape)	88	X	120	x
25	EM (End of medium)	89	Y	121	y
26	SUB (Substitute)	90	Z	122	z
27	ESC (Escape)	91	{	123	{
28	FS (File separator)	92	}	124	}
29	GS (Group separator)	93	:	125	:
30	RS (Record separator)	94	:	126	-
31	US (Unit separator)	95	-	127	DEL (Delete)
32	space	128	ç	160	à
33	!	ú	é	161	í
34	\$	ë	ó	162	ô
35	#	û	û	163	ô
36	*	ñ	ñ	164	ñ
37	%	ñ	ñ	165	ñ
38	&	ñ	ñ	166	ñ
39	*	ñ	ñ	167	ñ
40	(ñ	ñ	168	ñ
41)	ñ	ñ	169	ñ
42	,	ñ	ñ	170	ñ
43	+	ñ	ñ	171	ñ
44	,	ñ	ñ	172	ñ
45	-	ñ	ñ	173	ñ
46	=	ñ	ñ	174	ñ
47	/	ñ	ñ	175	ñ
48	0	ñ	ñ	176	ñ
49	1	ñ	ñ	177	ñ
50	2	ñ	ñ	178	ñ
51	3	ñ	ñ	179	ñ
52	4	ñ	ñ	180	ñ
53	5	ñ	ñ	181	ñ
54	6	ñ	ñ	182	ñ
55	7	ñ	ñ	183	ñ
56	8	ñ	ñ	184	ñ
57	9	ñ	ñ	185	ñ
58	:	ñ	ñ	186	ñ
59	,	ñ	ñ	187	ñ
60	<	ñ	ñ	188	ñ
61	=	ñ	ñ	189	ñ
62	>	ñ	ñ	190	ñ
63	?	ñ	ñ	191	ñ

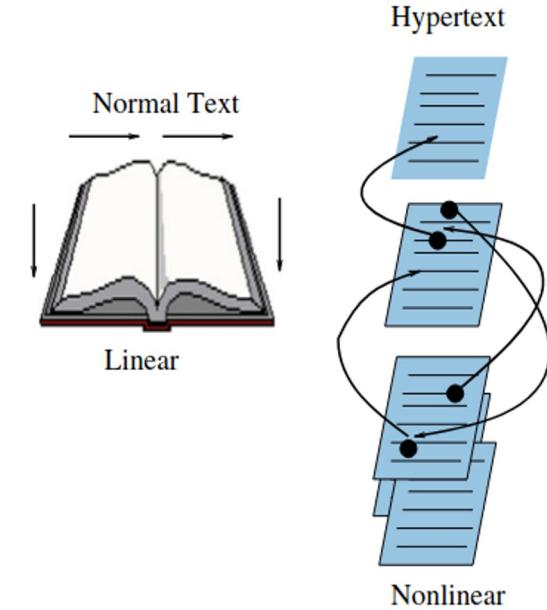
Formatted Text

- It is **rich or styled** text
- The purpose of formatted text is:
 - to enhance the presentation of information and
 - to help the reader to obtain, understand and retain information.
- It includes text formatting using specialized and customized style:
 - qualitative (e.g. fonts)
 - quantitative (e.g. font size or colour)
 - style of emphasis (e.g. bold or italics)
 - style of notation (e.g. strikethrough or superscript)
 - includes headers, paragraphs, sections, tables, equations, pictures, etc.



Hypertext

- ❑ The Xanadu project (1965) coined the term hypertext (i.e “magic place of literary memory”)
- ❑ Enables a related set of documents
 - referred to as pages
 - have defined linkage points - hyperlinks
- ❑ Allows to follow links that point to other parts of document or to other documents
- ❑ Very effectively used to retrieve information from databases and helps user in decision making
- ❑ User can process information faster and strategically.



Verified Exascale Computing for Multiscale Applications
The purpose of the VECMA project is to enable a diverse set of multiscale, multi-physics applications to run on current multi-petaflops computers and emerging exascale environments with high fidelity such that their output is ‘actionable’. That is, the calculations and simulations are certifiable (i.e. verified) to and equipped with uncertainty quantification (UQ) by tight error bars such that they may be relied upon for making important decisions in all the domains of concern. The central deliverable is an open source toolkit for multiscale VVUQ based on generic multiscale W and UQ primitives, to be released in stages over the lifetime of this project, fully tested and evaluated in emerging exascale environments, actively promoted over the lifetime of this project, and made widely available in European HPC centres.

VECMA in a Nutshell

Computer simulations are being used to predict the weather and climate change, model refugees, understand materials, develop nuclear fusion, and inform medical decisions. But if we are to use simulations in order to make predictions on the global climate emergency, guide aid to migrants fleeing combat, create new materials, help invent the first fusion reactor, and allow doctors to test medication on a virtual you (before the real you), then those simulations need to be reliable. In other words, they need to be validated, verified, and their uncertainty quantified, so that they can feed into real life applications and decisions. The VECMA project is developing software tools in order to validate, verify, and quantify the uncertainty on each of these simulation applications, and many besides.

Take a look at our "[VECMA Explained](#)" page to understand the key concepts at play.

2D Graphics and images

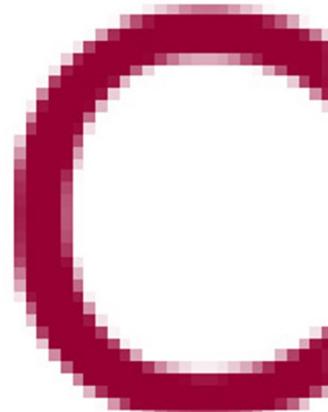
2D graphics



- Generation of digital images
- Mostly from two-dimensional models
- Started in the 1950s, based on vector graphics
- In the following decades, vector graphics largely supplanted by raster graphics.

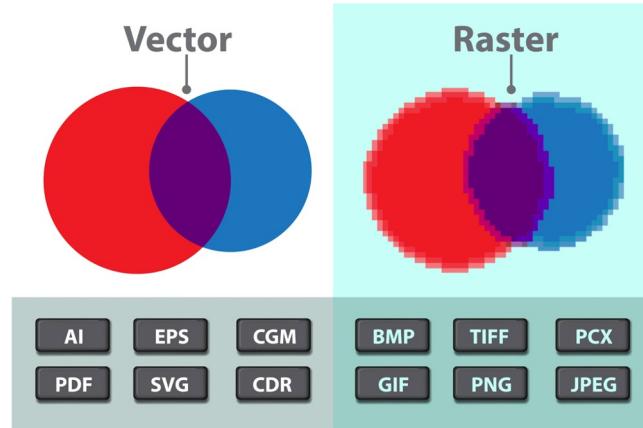


Vector



Raster

2D graphics and images



Vector:

- Object-oriented graphics
- Composed of paths
- File size scales with the number of paths (objects)
- Draw continuous and smooth lines
- Provide infinite zoom
- Cost more and occupy less space
- Saved by using file extensions, such as PDF, EPS, SVG, etc.

Raster (or Bitmap):

- Pixel-based graphics
- Composed of pixels
- File size scale with the resolution in pixels
- Draw mathematical curves, polygons, etc.
- Provide limited zoom
- Cost less and occupy more space depending on the image quality
- Saved by using file extensions, such as JPEG, GIF, BMP, etc.

Monochrome (or Binary) Images

- Each pixel is stored as a single bit (0 or 1)
- Two values are often 0 for black and 1 for white
- 1-bit monochrome image contains no colour
- Used for e.g. digital traffic indicators.

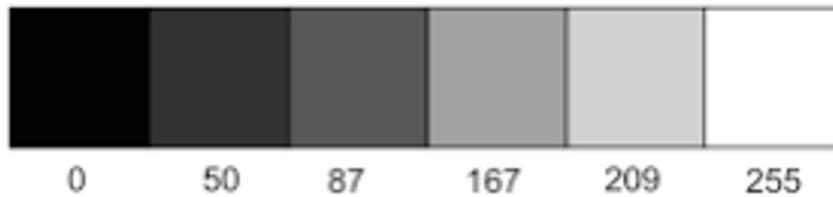


Pixel is the smallest unit of a digital image or graphic that can be displayed and represented on a digital display device.

Grayscale Images

Each pixel has a gray-value between 0 and 255 and represented by a single byte

- ❑ E.g., a dark pixel might have a value of 10, and a bright one might be 230.



Bitmap:

- ❑ The two-dimensional array of pixel values that represents the graphics/image data.

Grayscale Images

Image resolution:

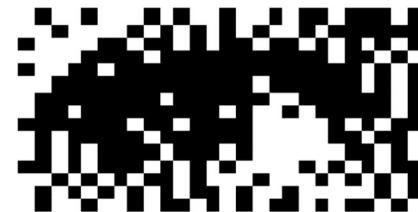
- # of pixels in a digital image (higher = larger and more detailed)
 - HD = 1280 x 720 pixels
 - Full-HD = 1920 x 1080 pixels
 - Multiply the two numbers to get a resolution measured in Megapixels (e.g. for cameras).

E.g. 640 x 480 grayscale image requires $307,200 = \sim 300\text{kB}$ of storage.



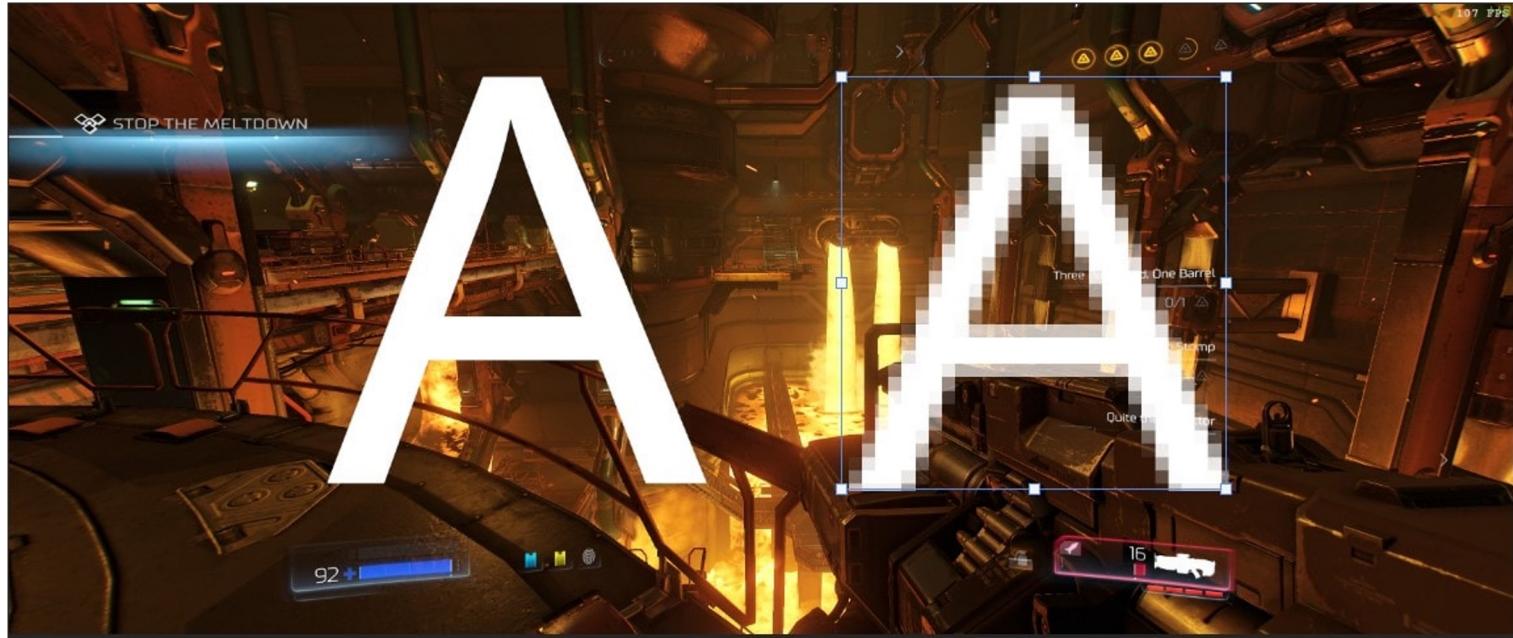
Dithering

- ❑ Often used for displaying monochrome images
- ❑ Creates the illusion of new colours and shades by varying the pattern of dots
- ❑ Takes advantage of the human eye's tendency to "mix" two colours in close proximity to one another
- ❑ E.g. Newspaper photographs are dithered.



Anti-aliasing

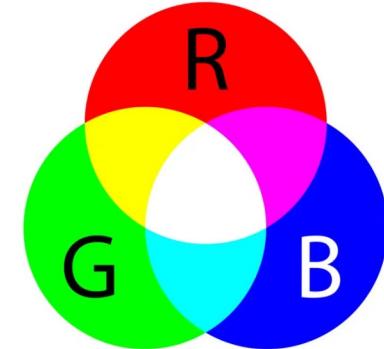
Anti-aliasing is the application of subtle transitions in the pixels along the edges of images to minimize the jagged effect.



Colour Images

All visible colour can be constructed by combining three primary colours:

- red, green and blue (RGB).



8-bit colour images:

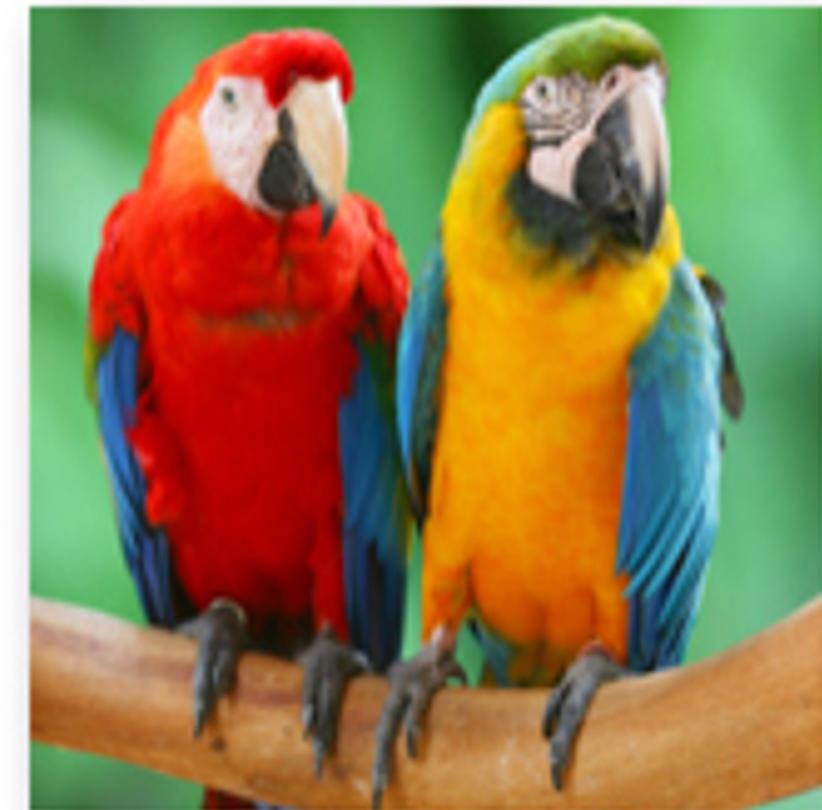
- 1 byte for each pixel
- supports 256 colours (out of the millions possible)

24-bit colour images:

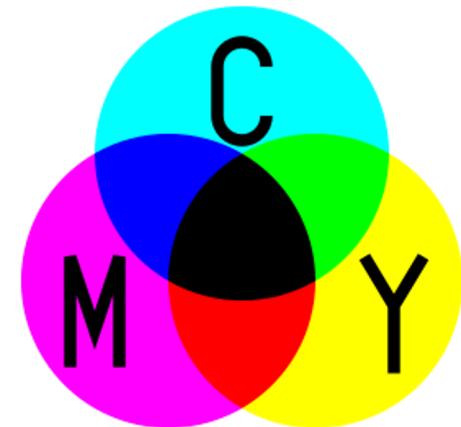
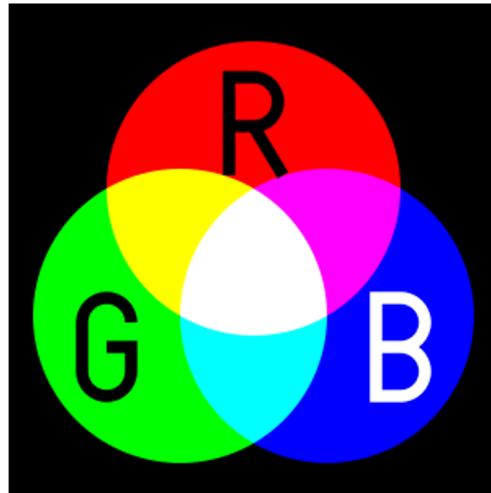
- Each pixel is represented by 3 bytes
- Supports $256 \times 256 \times 256$ possible combined colours
- Total of 16,777,216 possible colours.

We cannot display all colours on common computer screens, even if we had infinite bits per colour (!)

Can you guess which image is 24-bit?



Colour models



RGB (red, green, blue):

- Additive colours
- Mixing of colours begins with black (an inactive pixel) and ends with white (a fully light pixel)
- Best for websites and digital communications.

CMYK (cyan, magenta, yellow, black):

- Subtractive colours
- Mixing of colours begins with lightness (the paper) and ends with darkness (the pigment)
- Better for print materials.

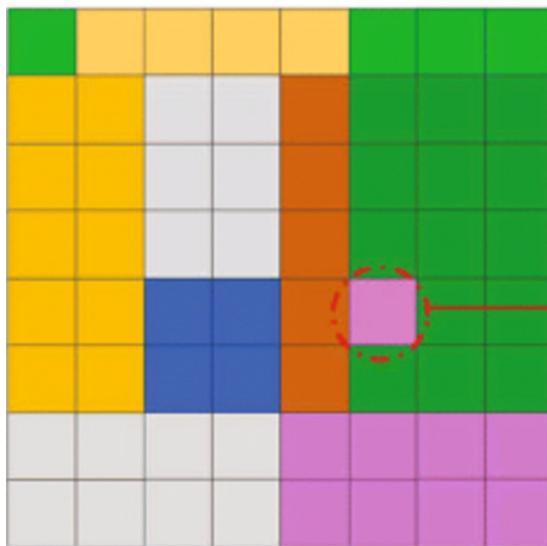
Indexed colour

Index	Red	Green	Blue
0			
1			
2	0-255	0-255	0-255
3			
4			
254			
255			

- Each pixel has one byte associated with it,
 - which is an index into a table of colours, called a palette or colour table
- Common in old consoles and used for animated gifs:
 - E.g. The Nintendo Entertainment System (NES) used a 16-colour palette based on a 256-colour space.



Indexed colour



(a) Indexed image

15	12	12	12	12	15	15	15
4	4	7	7	3	10	10	10
4	4	7	7	3	10	10	10
4	4	7	7	3	10	10	10
4	4	11	11	3	0	10	10
4	4	11	11	3	10	10	10
9	9	9	9	1	1	1	1
9	9	9	9	1	1	1	1

(b) Data matrix

	R	G	B
0	255	117	255
1	231	117	240
2	79	136	255
3	210	109	25
4	255	192	0
5	51	102	255
6	0	176	80
7	216	216	216
8	183	94	21
9	218	216	214
10	51	153	51
11	0	102	255
12	255	204	102
13	68	142	255
14	45	148	57
15	0	185	83

(c) Palette matrix

Image type and sizes

Image type	Bytes per pixel	Possible colour combinations
1-bit line art	$\frac{1}{8}$ byte per pixel	2 colours, 1 bit per pixel e.g. One ink on white paper
8-bit indexed colour	Up to 1 byte per pixel (if 256 colours)	256 colours maximum e.g. Used for graphics
8-bit grayscale	1 byte per pixel	256 shades of gray
16-bit grayscale	2 bytes per pixel	65636 shades of gray
24-bit RGB (8-bit mode)	3 bytes per pixel (one byte for each R, G, B)	16.77 million colours maximum
32-bit CMYK	4 bytes per pixel (for prepress)	C, M, Y and K inks typically in halftones
48-bit RGB (16-bit mode)	6 bytes per pixel	2.81 trillion colours maximum

Image type and sizes

- ❑ The most common colour depths today are 8-bit colour and 24-bit colour (true colour)
- ❑ The storage size for 24-bit is three times larger than that of a 8-bit image
- ❑ Some formats are restricted to particular hardware / operating system platforms, while others are “cross-platform” formats
- ❑ Many use compression to reduce storage size, can be classified as **lossless** or **lossy**
- ❑ Many 24-bit colour images are actually stored as 32-bit images, with the extra byte of data for each pixel used to store an alpha value representing special effect information (e.g., transparency).

Image file formats



Vector images
Curve-based graphics
Resolution independent
Logos, icons, & type

PDF
Print files and web-based documents

EPS
Individual vector design elements

AI
Original Adobe Illustrator design files

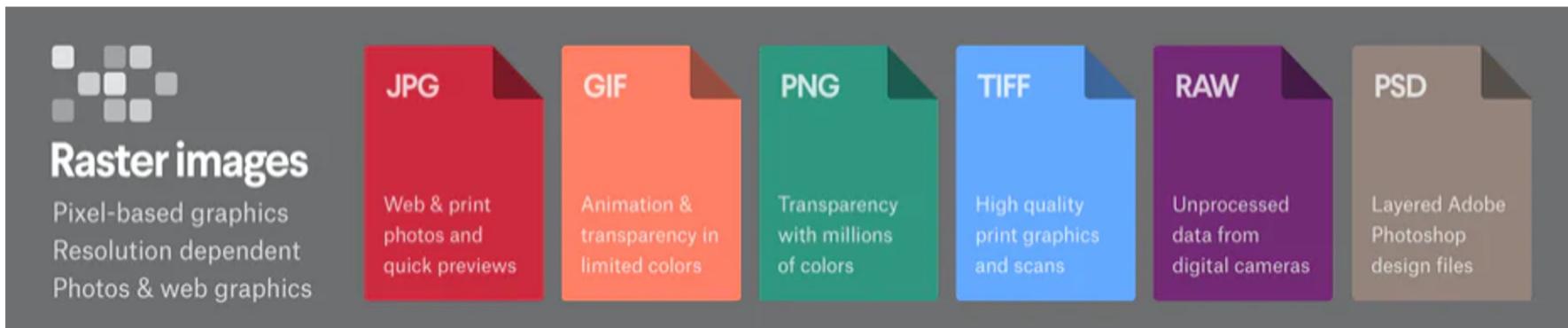
SVG
Vector files for web publishing

Extension	Name	Notes
.pdf	Portable Document Format	Save files that cannot be modified but still need to be easily shared and printed.
EPS, EPSF	Encapsulated PostScript File Format	Facilitate the incorporation of illustrations into textual documents for printing and transfers PostScript artwork between applications
.ai	Adobe Illustrator Artwork file	Vector based graphics contained in a single page and the graphics retains their details at maximum zoom level.
.svg	Scalable Vector Graphics	Extensible Markup Language (XML) based vector image format for two-dimensional graphics with support for interactivity and animation.

PDF and PS

- ❑ Postscript is an important language for typesetting, and many printers have a Postscript interpreter built into them
- ❑ Vector-based picture language:
 - Postscript includes text as well as vector/structured graphics
 - Graphics Library (GL) bit-mapped images can be included in output files
 - Encapsulated Postscript files add some additional information for inclusion of Postscript files in another document
 - Postscript page description language itself does not provide compression
 - In fact, Postscript files are just stored as ASCII.

Image file formats



Extension	Name	Notes
.jpg	Joint Photographic Experts Group	Lossy compression format well suited for photographic images.
.gif	Graphics Interchange Format	8-bit indexed bitmap format, is superseded by PNG on all accounts but animation.
.png	Portable Network Graphics	Lossless compression image, supporting 16-bit sample depth, and Alpha channel.
.tiff, .tif	Tagged Image File Format	Widely supported by scanning, faxing, word processing, optical character recognition, image manipulation, desktop publishing, and page-layout application.
.raw	Raw image file	Direct memory dump from a digital camera, contains the direct imprint from the imaging sensor, before layer interpolation and other colour corrections.
.psd	Photoshop Document	Native format of Adobe Photoshop, allows layers and other structural elements.

JPG or JPEG

- Uses discrete cosine transforms to provide lossy data compression, discarding small high-frequency patterns
- Allows the user to set a desired level of quality, or compression ratio (input divided by output)
 - Poorly compressed JPEGs often feature “blocky” artifacts.

GIF

- Uses 8-bit colour palettes, selected from a 24-bit colour space.
 - Animated gifs have 1 palette per frame (!)
- Uses Lempel-Ziv-Welch lossless data compression, which optimizes for repeating patterns.

GIF actually comes in three flavors:

1. GIF87a: The original specification
2. GIF89a: Supports e.g. simple animation, provides simple control over delay time, and a transparency index
3. Netscape Application Block (NAB): supports (infinite) loops since Netscape 2.0.

PNG

- ❑ Meant to supersede the GIF standard and extends it in important ways
- ❑ Special features of PNG files include:
 - Support for up to 48-bits of colour information
 - Files may contain gamma-correction information for correct display of colour images, as well as alpha-channel information to control transparency
 - The display progressively displays pixels in a 2-dimensional fashion by showing a few pixels at a time over seven passes through each 8x8 block of an image.

TIFF

The support for attachment of additional information (referred to as “tags”) provides a great deal of flexibility

- ❑ The most important tag is a format signifier: what type of compression is in use in the stored image
- ❑ Can store many different types of image: 1-bit grayscale, 8-bit colour, 24-bit RGB, etc.
- ❑ Originally a lossless format but now a new JPEG tag allows one to opt for JPEG compression
- ❑ Common for digital cameras.

**TIME FOR A
BREAK**



Animations

Animation

- ❑ A collection of still images with each one in the sequence slightly different from the previous
- ❑ Image designed to change over a period of time
 - to give the illusion of movement
 - known as the frame rate
- ❑ Techniques are almost common e.g. games, films and websites.



Animation

To create an animation:

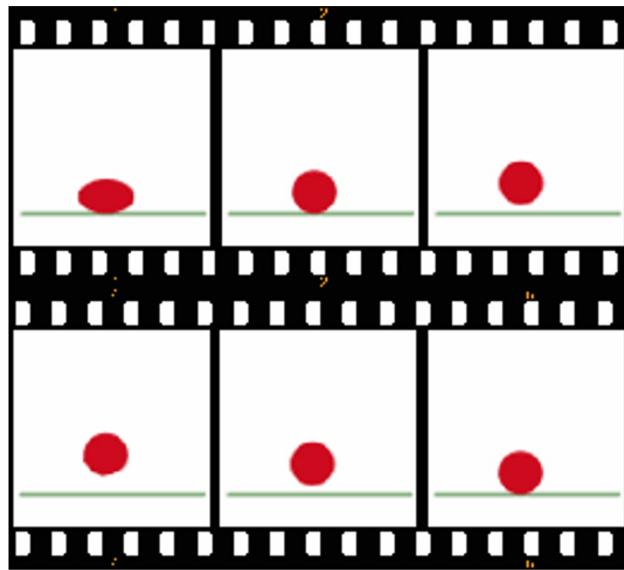
- Organise the execution in a series of logical steps
- Choose an animation tool best suited for the task
- Build and tweak the sequence
- Postprocess the completed animation.

Types of animation

- Hide and show animation
- Moving objects
- Image replacement
- Zoom and resize
- Colour cycle animation.

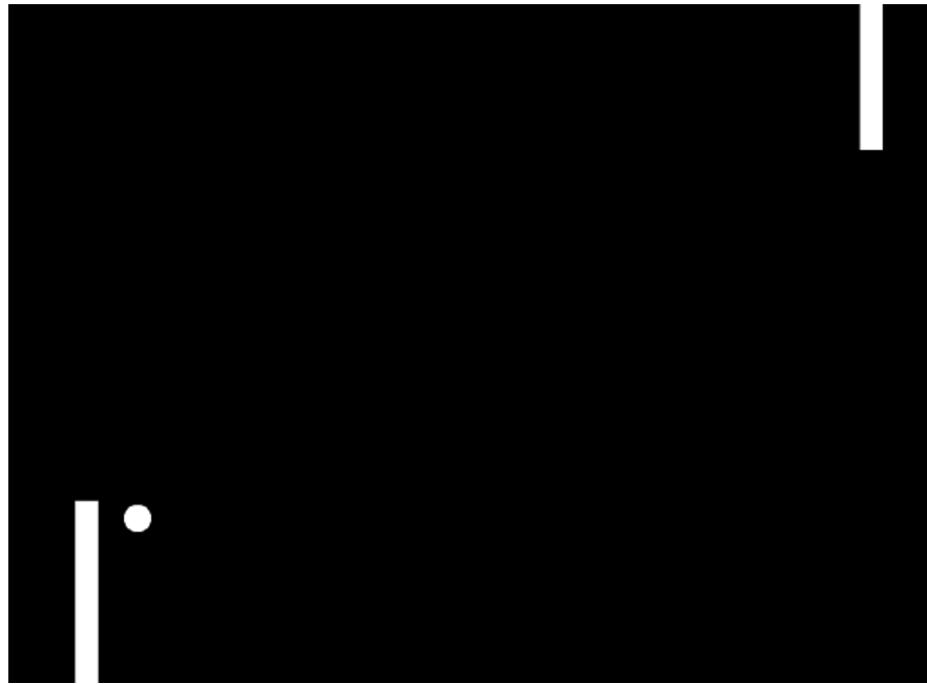
Hide and show animation

- Create all objects
- Select number of images are shown
- Timing of when objects are visible creates the illusion of animation.



Moving objects

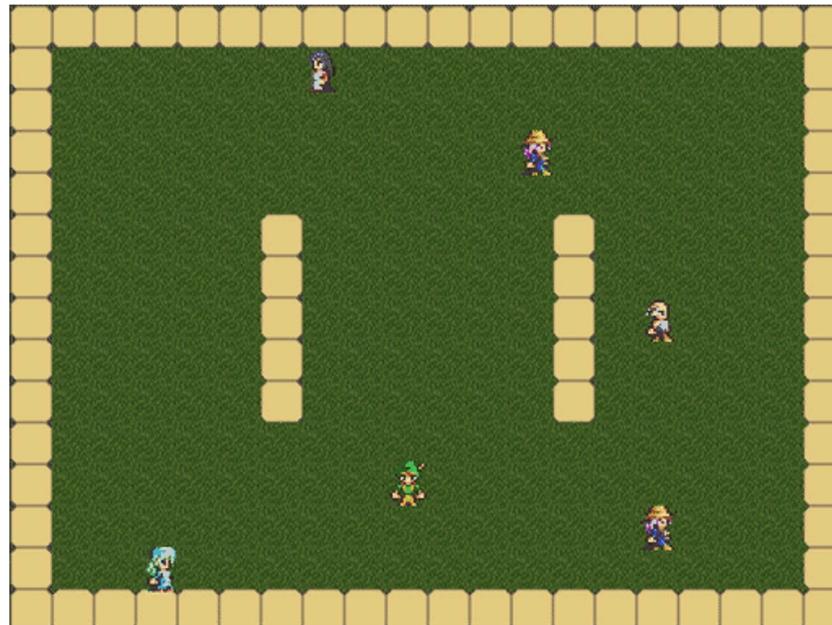
Objects are placed on the screen and controlled by a software program which moves them around the screen as required.



Source: http://kidscancode.org/blog/2018/01/godot3_inheritance/

Image replacement

- ❑ Entities are animated by changing in between frames in a sprite set.
- ❑ Different frames may be rendered based on
 - e.g. time intervals or the orientation/facing of the entity.



Zoom and Resize

The boundaries of objects on the screen are changed under program control.

By resizing a series of objects on a screen one can create the impression of animation.



Colour cycle animation

- ❑ Change values of colour components.
- ❑ Can create e.g. the illusion of flows.
- ❑ Used in old school computer games.

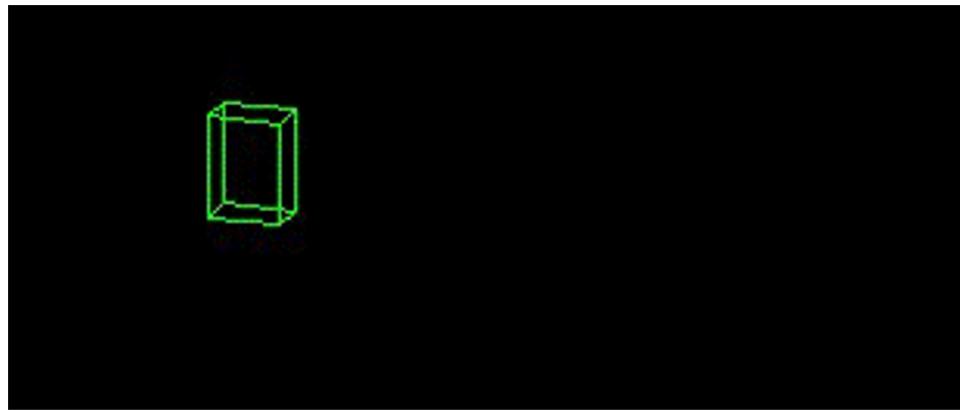
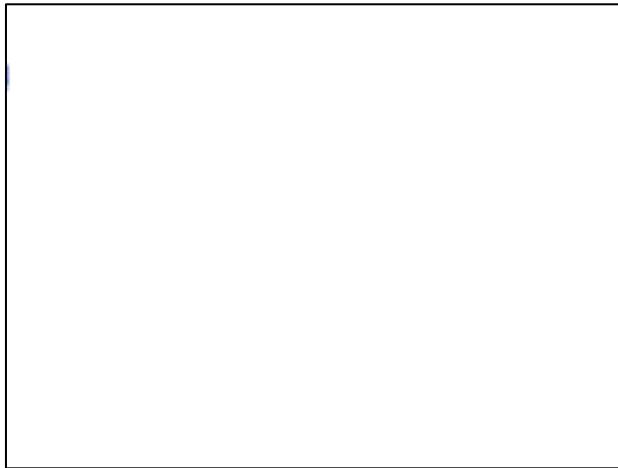


Source: <https://imgur.com/r/pixelart/zfmq5TZ>



Keyframing and inbetweening

- ❑ A **keyframe** in animation and filmmaking is a drawing that defines the starting and ending points of any smooth transition.
- ❑ Programs can then interpolate the frames in between. This is called **inbetweening** or tweening.
- ❑ One can tween based on shape, color, or location.



When did you use graphics and images in your game?

Sprite:

- a character or figure within a game. Sprites usually have a transparent outline and can be animated to simulate movement



Background image:

- an image that shows landscape of a game.



Animation file formats

- “Silent” animation formats (like animated gifs)
- Full motion video formats
- Streaming formats.

GIF and GIFV

- ❑ Animated version of GIF image format
- ❑ But compression is poor, and file sizes can get very large
- ❑ GIF89a allows multiple images to be put into a single file and displayed as an animation
- ❑ Animations do not provide interface controls
- ❑ .gifv is now widely used, but is not a video file in the classical sense
 - File size can be around 95% smaller than normal .gif files
 - Used by imgur.com. Sites like gfycat.com do similar conversions.

APNG

- ❑ Animated version of PNG files
- ❑ First image is written as a PNG stream, allowing the first frame to be visualized on non-supporting platforms
- ❑ Established in 2008
- ❑ 24-bit color + 8-bit transparency
- ❑ Better compression performance than animated gifs or webp files.

WEBP

- ❑ Animation format that supports both lossless and lossy compression
- ❑ Originally developed by Google, widely used today, but not supported by Google Slides (!)
- ❑ Doesn't clearly outperform JPEG for still images, and doesn't clearly outperform APNG for animations.



Audio in Games

Audio

- Sound of any type played in a game
 - Dialogue / speech sounds
 - Sound effects
 - Music / score
 - Ambience
 - Interface sounds.



Types of game audio

- ❑ Static:
 - Ongoing throughout the game, e.g. background music
- ❑ Interactive:
 - Triggered by specific actions from the player
- ❑ Adaptive:
 - Triggered by changes in the gameplay environment, but not directly by player actions
- ❑ Dynamic:
 - Refers to both interactive and adaptive audio.

Functions of game sound

- Commercial functions
- Reinforce game structure
- Immersion / suspension of disbelief
- Semiotics functions
- Narrative functions
- Emotional functions
- Aesthetic functions
- Kinetic functions.

Semiotic functions

- Sonic symbols / leitmotifs: identify symbols, decrease steepness of learning curve.
- Preparatory function.
- Focus attention and identify goals
- Convey meaning, emotion.
- Add slant or bias.

Narrative functions

- Plot advancements
- Locate player in storyline
- Foreshadow
- Access character's thoughts / reveal character's details
- Dialogues
- Reveal goals.



Emotional, aesthetic & kinetic functions

- Emotional / physiological: manipulate player
- Create moods
- Create intimacy
- Indicate genre/style of a game (e.g., use of a western tune)
- Music as motivating factor for movement
- Edutainment for toddlers etc.



Common audio problems in games

- ❑ Mixing: too many sounds, timing errors, no “post-production”
- ❑ Poor sampling/compression
- ❑ Caused by space limitations
- ❑ Transitions from cue to cue
 - Abrupt jumps between sounds, bad or no transitions
 - Solved e.g. with cross-fades
- ❑ Listener fatigue
 - Use silence(!), avoid infinite loops, variability.



Today's session:

Text

2D graphics and images

Animations

File formats

Audio in games

Key readings

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