



IDX G9 Computer Science S
Study Guide Semester 1 Finals
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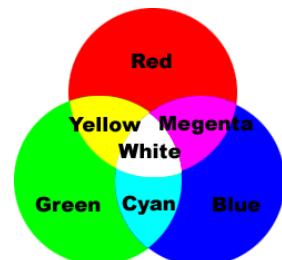
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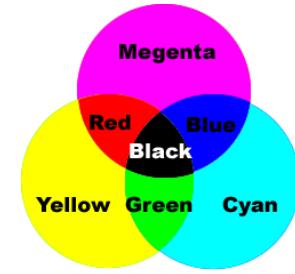
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2.1 Computer Colors

- A computer's primary colors are **red, green and blue**
 - all colors we generate form the three spectral hues of red, green and blue

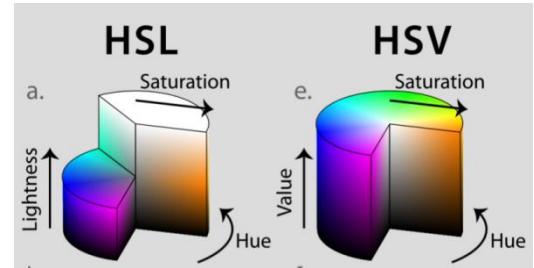


- CMYK: proper reference for printed color
- HSV/HSL/HSI
 - H: Hue -> the pure dominant color (original colorness)
 - S: Saturation -> intensity/purity of a color
 - V: Value -> lightness or darkness
 - L: Lightness -> color's brightness (amount of black/white)
 - I: Intensity -> brightness or dullness of a color



- Binary notation of colors: 24 numbers to represent a color

- EG: 111111 111111 111111 is white
- The first 6 “1”s represent the red part of the color, the next group of “1”s represent the green part and the last group of “1”s represent the blue part



- Hexadecimal: using 6 letters/numbers to represent a color
 - EG: #FF FF FF represents white
 - The first group of “F”s represent the red part, the second group represents green, and the third group represents blue

- Ways to store characters:

- **Morse code:** the use of dots and dashes. This can be ineffective as letters can be mixed up
- **ASC II:** developed from telegraph codes, encodes 128 specified characters into **7-bit integers**
- For letters, it is a capital letter, start with “10” and lowercase letters start with “11”

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0 000	NUL	(null)	32	20 040	0#32;	Space	64	40 100	0#64;	0	96	60 140	0#96;	‘			
1	1 001	SOH	(start of heading)	33	21 041	0#33;	!	65	41 101	0#65;	A	97	61 141	0#97;	a			
2	2 002	STX	(start of text)	34	22 042	0#34;	”	66	42 102	0#66;	B	98	62 142	0#98;	b			
3	3 003	ETX	(end of text)	35	23 043	0#35;	#	67	43 103	0#67;	C	99	63 143	0#99;	c			
4	4 004	EOT	(end of transmission)	36	24 044	0#36;	\$	68	44 104	0#68;	D	100	64 144	0#100;	d			
5	5 005	ENQ	(enquiry)	37	25 045	0#37;	%	69	45 105	0#69;	E	101	65 145	0#101;	e			
6	6 006	ACK	(acknowledge)	38	26 046	0#38;	&	70	46 106	0#70;	F	102	66 146	0#102;	f			
7	7 007	BEL	(bell)	39	27 047	0#39;	‘	71	47 107	0#71;	G	103	67 147	0#103;	g			
8	8 010	BS	(backspace)	40	28 050	0#40;	(72	48 110	0#72;	H	104	68 150	0#104;	h			
9	9 011	TAB	(horizontal tab)	41	29 051	0#41;)	73	49 111	0#73;	I	105	69 151	0#105;	i			
10	A 012	LF	(NL line feed, new line)	42	2A 052	0#42;	*	74	4A 112	0#74;	J	106	6A 152	0#106;	j			
11	B 013	VT	(vertical tab)	43	2B 053	0#43;	+	75	4B 113	0#75;	K	107	6B 153	0#107;	k			
12	C 014	FF	(NP form feed, new page)	44	2C 054	0#44;	-	76	4C 114	0#76;	L	108	6C 154	0#108;	l			
13	D 015	CR	(carriage return)	45	2D 055	0#45;	-	77	4D 115	0#77;	M	109	6D 155	0#109;	m			
14	E 016	SO	(shift out)	46	2E 056	0#46;	.	78	4E 116	0#78;	N	110	6E 156	0#110;	n			
15	F 017	SI	(shift in)	47	2F 057	0#47;	/	79	4F 117	0#79;	O	111	6F 157	0#111;	o			
16	10 020	DLE	(data link escape)	48	30 060	0#48;	0	80	50 120	0#80;	P	112	70 160	0#112;	p			
17	11 021	DC1	(device control 1)	49	31 061	0#49;	1	81	51 121	0#81;	Q	113	71 161	0#113;	q			
18	12 022	DC2	(device control 2)	50	32 062	0#50;	2	82	52 122	0#82;	R	114	72 162	0#114;	r			
19	13 023	DC3	(device control 3)	51	33 063	0#51;	3	83	53 123	0#83;	S	115	73 163	0#115;	s			
20	14 024	DC4	(device control 4)	52	34 064	0#52;	4	84	54 124	0#84;	T	116	74 164	0#116;	t			
21	15 025	NAK	(negative acknowledgement)	53	35 065	0#53;	5	85	55 125	0#85;	U	117	75 165	0#117;	u			
22	16 026	SYN	(synchronous idle)	54	36 066	0#54;	6	86	56 126	0#86;	V	118	76 166	0#118;	v			
23	17 027	ETB	(end of trans. block)	55	37 067	0#55;	7	87	57 127	0#87;	W	119	77 167	0#119;	w			
24	18 030	CAN	(cancel)	56	38 070	0#56;	8	88	58 130	0#88;	X	120	78 170	0#120;	x			
25	19 031	EM	(end of medium)	57	39 071	0#57;	9	89	59 131	0#89;	Y	121	79 171	0#121;	y			
26	1A 032	SUB	(substitute)	58	3A 072	0#58;	:	90	5A 132	0#90;	Z	122	7A 172	0#122;	z			
27	1B 033	ESC	(escape)	59	3B 073	0#59;	:	91	5B 133	0#91;	[123	7B 173	0#123;	{			
28	1C 034	FS	(file separator)	60	3C 074	0#60;	<	92	5C 134	0#92;	\	124	7C 174	0#124;	\			
29	1D 035	GS	(group separator)	61	3D 075	0#61;	=	93	5D 135	0#93;]	125	7D 175	0#125;	}			
30	1E 036	RS	(record separator)	62	3E 076	0#62;	>	94	5E 136	0#94;	^	126	7E 176	0#126;	~			
31	1F 037	US	(unit separator)	63	3F 077	0#63;	?	95	5F 137	0#95;	_	127	7F 177	0#127;	DEL			

Source: www.LookupTables.com

- Graphic formats can be formatted in:
 - GIF, shows 256 kinds of colors at most in one picture

- JPEG: millions of kinds of colors ($2^8 \times 2^8 \times 2^8 = 16777216$), saves memory space in computer
- PNG: combines advantages of GIF and JPEG, good quality, can be transparent, not very popular as many web pages cannot show pictures in this format
- BMP/RLE: one of the most popular formats used to save images on windows operating system
- PSD: used in photoshop, save all detailed elements made in photoshop such as layers, color modes, path and channel etc, occupy large memory in computer but can be compressed
- HEIF: supports multiple bit depths, depending on the encoder and use case, memory is about 50% smaller than the JPEG format, shows billions of colors (2^{30}), records images with richer information, compatibility is limited
- bit depth: color depth per channel, not the total file size or container overhead

2.2 Digital Graphics

- An image created/edited on a computer is either a bitmapped or vector graphic
 - **Bitmapped:** AKA raster graphics, consists of pixels, if you enlarge a bitmap you enlarge a pixel
 - pixels become more obvious and image loses crispness and clarity
 - **Vector:** uses mathematical formulas to define lines, curves and other attributes of digital images
 - you use vector graphics editing program
 - Vector files are generally much smaller than bitmapped
- The number of **pixel per inch** (ppi) determines the resolution of bitmap graphics
 - photo display on a computer screen usually looks realistic at 72 ppi
 - vector graphics do not rely on resolution for clarity, but its' display on a computer screen does
- **color depth:** in graphic files and applications, color depth refers to the number of distinct colors an image can contain/how many bits per pixel
 - EG 24-bit image has color depth of 16.7 million colors, called **full color image**

- **Field of View/Field of vision (FOV):** extent of observable world that is seen at any given moment
 - Humans have ≈210 degree of forward facing horizontal arc of their visual field'
 - vertical range of the visual field in humans is around 150 degrees
 - some birds have complete/nearly complete 360 degree FOV
- **Aspect ratio:** relationship between its width and height
 - expressed as (x,y)
 - common aspect ratios: 5:4, 4:3, 16:10, 16:9
- Brief history
 - **2003:** most computer monitors had 4:3 aspect ratio, some had 5:4
 - **2003-2006:** 16:10 became common in laptops and standalone monitors
 - **2008:** industry moved from 4:3 and 16:10 to 19:9 as the standard ratio
 - **2010:** All monitors and laptops moved to 16:9 aspect ratio
 - **2011:** 16:9 reso of 1920*1080 became popular among steam users
 - **2012:** resolution became 1366*768

2.3 Alpha Channel

- **alpha compositing:** process of combining an image with a background to create the appearance of partial or full transparency
 - keep an associate matte for each element
 - In a 2D image element, which stores a color for each pixel, additional data is stored in the alpha channel with a value between 0 and 1
 - 0 means pixel does not have any coverage info and is transparent
 - 1 means the pixel is opaque because the geometry overlapped the pixel
 - one more number is required to store **alpha**
 - from (148,255,255) to (148,255,255,0)
 - first 3 numbers imply the color
 - last three imply the alpha
- if three primary colors share the same number, this color contains only brightness, it can only be black, white or gray

- (0,0,0) is black
- (255,255,255) is white
- (100,100,100) is gray
- **premultiplied alpha:** if the alpha channel is used in an image, it's common to also multiply the color by the alpha value
 - saves space
 - **linear interpolation:** given two red points, the blue line is the linear interpolate between the points, and then value y at x may be found using this method

2.4 Computer monitors

- **computer monitors:** the size of a display is usually given by monitor manufacturers based on the diagonal
 - measure in unit inch
 - display devices: cathode ray tube (CRT), liquid crystal display (LCD), organic light-emitting diode (OLED)
 - **CRT:** old fashioned, vacuum tube containing an electron gun and phosphorescent screen used to view images
 - **LCD:** most common, has diffraction grating, crystal and backlight
 - **OLED:** monitor of the future, simple structure, self emissive

2.5 Image Compression

- **uncompressed image - raw file:** captured by a digital camera or scanner's sensors, this captures a high level of image detail, with large file sizes and lossless quality
 - direct image data means you start with a high-quality image that can be edited, converted and compressed in a non-destructive manner
- **lossy vs lossless**
 - lossless: preferred for archival purposes, for medical imaging, technical drawings, clip art, comics
 - lossy: suitable for natural images EG photographs in applications
- **lossless compression**

- Run-length encoding (RLE) is a simple form of data compression where runs of data are stored as a single data value and count, rather than as the original run
 - example of RLE: W representing white and B representing black:
WWWWWWBWW
 - instead this can be compressed into 5W1B2W
- Differential pulse-code modulation (DPCM) encodes the changes between consecutive samples of a signal rather than the signal's value directly
 - reduces the bit rate
 - input can be an analog signal or digital signal
 - methods of encoding:
 - quantize the samples, output is the difference between the current and previous sample
 - quantize the difference between the current sample and output of a local decoder
 - color space is reduced to the most common colors, these selected colors are defined in a color palette stored within the image header
 - each pixel references the index of its corresponding color in the palette
 - this approach can be combined with dithering to minimize posterization artifacts
- **entropy encoding:**
 - **Huffman coding:** separating the input into component symbols and replacing each with a code, uses variable length codes to represent different characters
 - shorter codes -> assigned to more frequently occurring characters and longer to less frequent ones, results in compressed data representation
 - optimal for minimizing the total number of bits used
 - **Arithmetic coding:** encoding the entire message into a single number, a fraction n where $(0 \leq n \leq 1)$
- **chroma subsampling:** human eye perceives spatial changes of brightness more sharply than color, so this method averages/drops some of the chrominance info in the image

- **transform coding:** most commonly used method, Fourier related transform such as the **discrete cosine transform (DCT)** is widely used
 - wavelet transform is also used extensively, followed by quantization and entropy coding

3.1 Frame Rate

- **Video: fast switching pictures**
 - Frame rate: AKA frame frequency/frames per second (FPS); the frequency at which an imaging device produces unique consecutive images called frames
 - unit: FPS, Hz(Hertz)
 - threshold of human visual perception: 24 fps
- Standard frame rates in cinema/TV: 24 fps(cinematic films), 25 fps(PAL(Asia), SECAM(Europe)), 30 fps(NTSC, North America).
- 24 fps: progressive format, transferring video signal to film (fps of film: 23.976)
- 48 fps: progressive format trialed in the film industry, reduce motion blur and flicker, EG “The Hobbit”
- 50 or 60 fps: HDTV/video in high definition based on 25 and 30 fps

3.2 Data Rate and Bandwidth

- Stream: sequence of data elements made available over time
 - divides a video into several parts, which are transported one by one, while one part is playing the next is being loaded
- Bandwidth: measurement of bit-rate of available or consumed data communication resources expressed in bits per second or multiples of it
- Data rate: speed of stream transmission
 - decides how much data will be transported each second
 - Conversion:
 - 1 TB = 1024 GB
 - 1 GB = 1024 MB
 - 1 MB = 1024 KB (Kilobyte)
 - 1 KB = 1024 Byte

- 1 Byte = 8 bit
- Data rate = File size (bit) / length of file (sec)
- unit of data rate and bandwidth are both bps (bits per second)
- data rate is determined by: screen size, frame rate, and codec
 - data rte of SD vid: around 512 KB-2M
 - data rate of 720P vid: 4MB-16MB
 - data rate of 1080 vid: 8MB-48MB
- Bandwidth of our internet connection should be larger than the data rate of video

3.3. 3D Vision

- 3D vision: we see two 2D images separately with our left and right eye, our brain combines them and gives a 3D depth
- **Anaglyph 3D:**
 - stereoscopic 3D effect achieved by means of encoding each eye's image using filters of different colors, typically red and cyan
 - contain two differently filtered colored images, one for each eye
 - color filters to create 3D effect, eg. red-cyan color filters
- **Polarization 3D system:**
 - polarization glasses to create the illusion of 3D images by restricting the light that reaches each eye
 - low-cost eyeglasses which contain a pair of different polarizing filters
 - two images are projected superimposed on the same screen or display through different polarizing filters
 - linear polarizer converts an unpolarized beam into one with a single linear polarization:
 - vertical components of all waves are transmitted
 - horizontal components are absorbed and reflected
- **Active Shutter 3D system:**
 - openly presenting the image intended for the left eye while blocking the right eye's view, then presenting the right eye's image while blocking the left eye

- this is repeated rapidly so that the interruptions do not interfere with the perceived fusion of the two images into a single 3D image
- EG NVIDIA 3D vision system
- **HUD:**
 - Head mounted display (HMD): display device worn on the head/part of a helmet, has a small display optic in front of one or each eye
 - EG Google Glasses

3.4 Video Compression

- **Uncompressed:** stores every single data of a video, both useful and useless
 - loses no quality during the process of editing or copying from one form of media into another
- **video compression:** encoding or decoding a digital data stream or signal
 - **lossless:** used for archiving data in a compressed form while retaining all the information present in the original stream
 - **lossy:** reduce quality by some amount in order to achieve compression, formats include mpeg, mov, mkv
 - **encoder/decoder:** used in multi-media area for video compression and decompression
 - **codec and format:** old time codec and format are strongly related, even the players are related to the codecs
 - usually format and codec are in pairs, but not always
 - sometimes we cannot open a video with one format while another video with this format can be opened
 - **container format:** special video format that allowed the users to encode videos with different codecs but sharing the same format name or extension
 - eg. AVI, QuickTime(MOV), Mpeg4 etc
 - contain different codecs but allows users to encode audio/vid with different compressors

- Video support:

	MPE 2.1	MPE 2.2	MPE 2.4	H.264	H265	WMV	Real	Theo	MS MP4	VP8	VP9	MVC
	MP3	WMA	Vorbis	Opus	AAC	AC-3	DTS	PCM	FLAC	ALAC	DD-HD	DTS-HD
AVI			Not Off	?								?
MP4			Not Off	?	Possible							
MXF			?	?								
Ogg												
MOV				?			?					
WebM												
Matroska												

- Audio support:

3.5 Video Connectors

- **Video connectors:** electric connectors for carrying video signal, of either analog or digital format
 - both analog and digital signals are used with some styles of connectors, knowledge of the interface used is necessary for a successful signal transmission
 - some interface types use only a distinctive connectors or family of connectors to ensure compatibility
- **VGA(Video Graphic Array):** three-row 15-pin connector, the 15-pin VGA connector is found on many video cards, computer monitors, and high definition TV sets
 - same VGA cable can be used with a variety of supported VGA resolutions
 - ranging from 640*350 px at 70 Hz to 1280*1024 px at 85 Hz and up to 2048*1536 px at 85 Hz
 - 25 MB/s
- **DVI(Digital Visual Interface):** designed to transmit uncompressed digital video, can be configured to support multiple modes, DVI-D, DVI-A, or DVI-I
 - Digital vid stream: 1920*1200 at 60 Hz - 2560*1600 at 60 Hz
 - Analog vid stream: 1920*1200 at 60 Hz

- 7.92 Gbits/s
- **HDMI:** Proprietary audio/video interface for transferring uncompressed video data and compressed or uncompressed digital audio data
 - 2.25 GB/s
- **Thunderbolt:** 40 Gbits/s

Interface			Connector
Video Only	Analog	Video Graphic Array(VGA)	D-subminiature(15 pins)
	Digital and Analog	Digital Visual Interface(DVI)	DVI connector
Video and Audio	Digital	High-Definition Multimedia Interface(HDMI)	HDMI connector
		Display Port	DisplayPort connector
		Thunderbolt	Mini Display Port (in version 1 and 2) or USB-C(in version 3 and 4)

3.6 Storage Devices

- **Magnetic storage:** uses different patterns of magnetisation in a magnetisable material to store data is a form of non-volatile memory
 - Analog recording
 - Digital recording: floppy disk, hard disk

- **Optical storage:** optical disc is a flat, usually circular disc which encodes binary data in the form of pits (0) and lands (1) on a special material (aluminum) on one of its flat surfaces
 - CD, DVD, HD DVD, Blue-Ray
- **Flash storage:** electron non-volatile computer storage medium that can be electrically erased and reprogrammed
 - memory cards
 - USB flash drives
 - solid-state drives (SSD)