

Image File Formats

Knox Game Design

April 2021

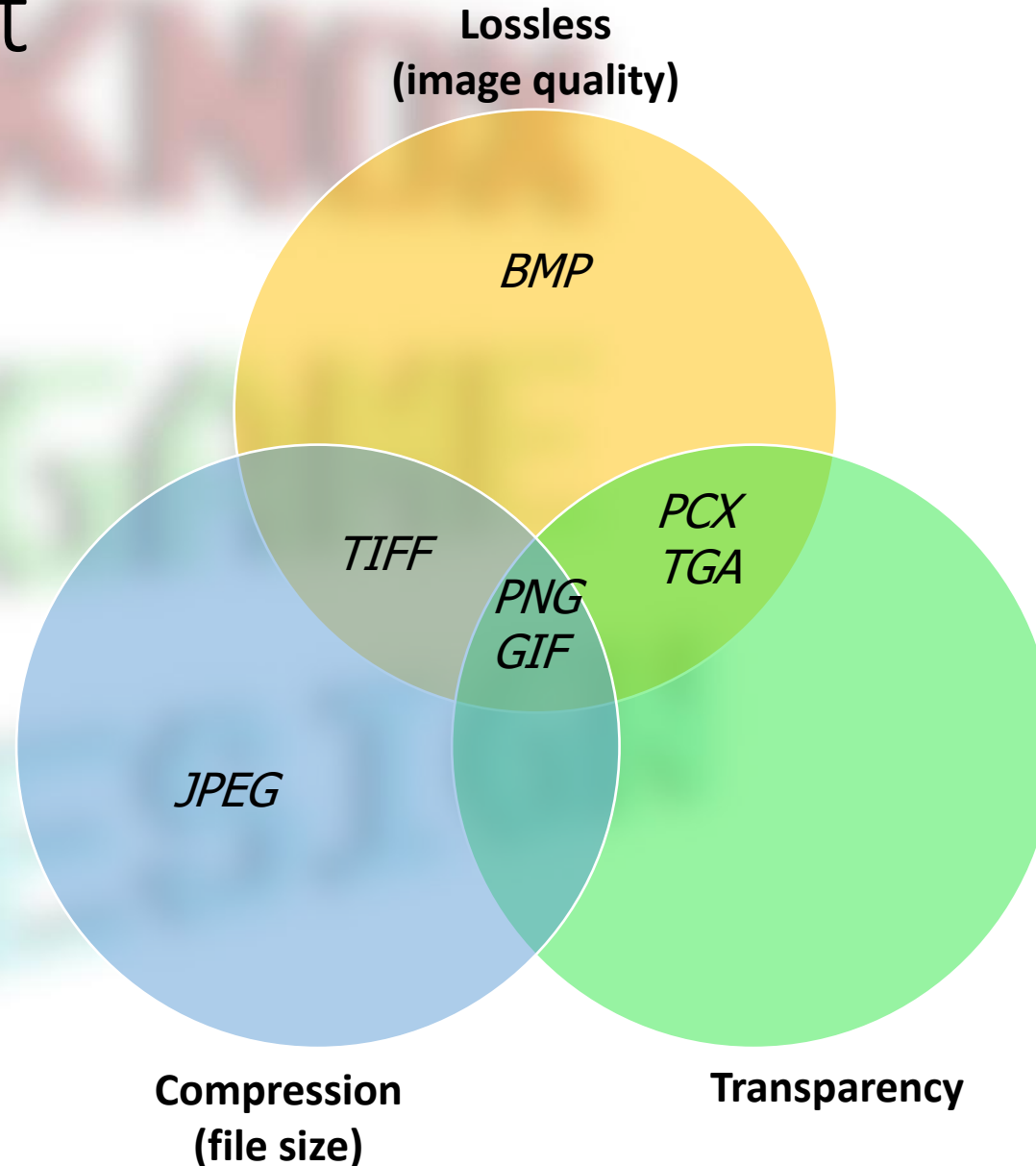
Levi D. Smith

Why are File Formats Important

- File size / Compression
- Color depth
- Transparency
- Array vs vector graphics

Choosing a Format

- Lossless - No reduction in image quality (raw image data, working copy, long term storage)
- Lossy - Possible loss in image quality
- Compression - Data is compressed to reduce file size



**TIFF can be lossy or lossless*

File size

- File sizes for a 64x64 image with 16 colors and transparency
- Top row: Hue += 45
- Bottom row: RGB, 3 bits incremented (000 to 111)

```
$ ls -lsr
```

588	color_test.gif
711	color_test.png
1396	color_test.jpg
1760	color_test.pcx
2358	color_test.xcf
2604	color_test.tga
16522	color_test.bmp
214142	color_test.tiff

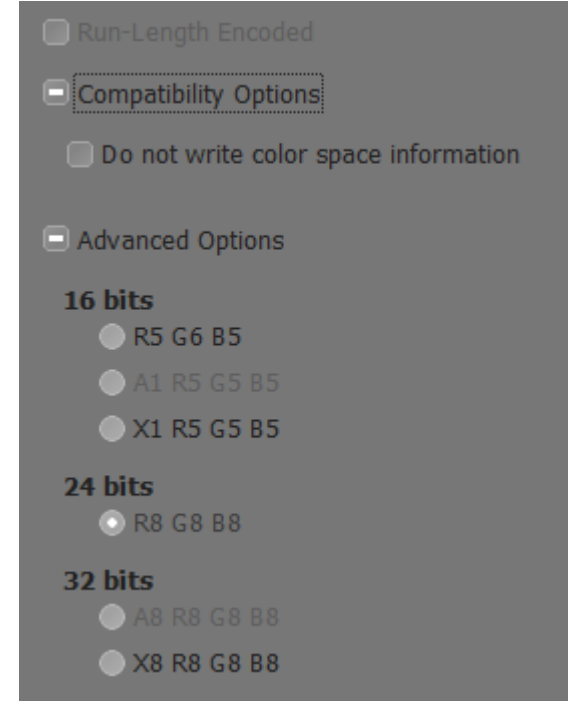


**JPG compression: 60*

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BMP

- Developed by Microsoft, 1985
- Lossless, large file size
- Specification
 - <https://docs.fileformat.com/image/bmp/>
 - <https://www.loc.gov/preservation/digital/formats/fdd/fdd000189.shtml>



GIF

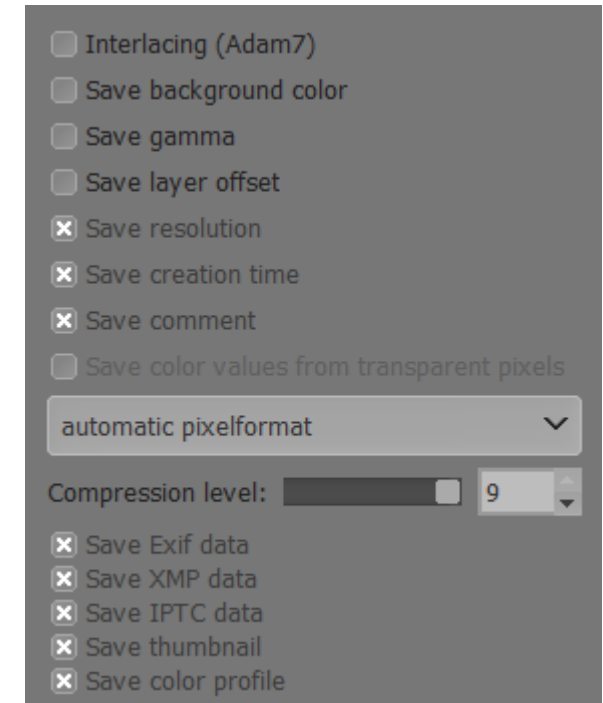
- Graphics Interchange Format
- Developed by team at CompuServe led by Steve Wilhite, 1987
- Specification
 - <https://www.w3.org/Graphics/GIF/spec-gif89a.txt>
 - <https://docs.fileformat.com/image/gif/>
- Only 256 indexed colors
- Allows for animation
- Transparency
- LZW compression (proprietary)



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PNG

- Portable Network Graphics (PNG is not GIF)
- Developed by "PNG Working Group", 1995
- Specification
 - RFC 2083
 - ISO/IEC 15948
 - <https://www.w3.org/TR/PNG/>
- APNG for animations (supported by major web browsers)
- Compression uses zlib format and LZ77 for image data

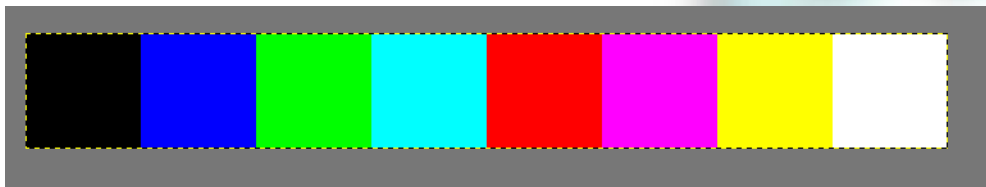


Tip - Uncheck options such as color profile to get a significantly smaller file

564 bbgcamyw_png.png
93 bbgcamyw_png2.png

PNG Format (Chunks)

```
1 137 80 78 71 13 10 26 10= Signature (%PNG)
2
3 0 0 0 13 = length: 13
4 73 72 68 82 = type: IHDR
5 0 0 0 8 0 0 0 1 8 2 0 0 0
6 108 98 120 20 = crc
7
8 0 0 1 132 = length: 388 (256 + 132)
9 105 67 67 80 = type: iCCP
10 73 67 67 32 112 114 111 102 105 108 101 0 0 40 145 125 145 61 72
195 64 28 197 95 63 164 69 42 130 118 40 226 144 161 58 89 144 42
226 40 85 44 130 133 210 86 104 213 193 228 210 47 104 210 144 164
184 56 10 174 5 7 63 22 171 14 46 206 186 58 184 10 130 224 7 136
155 155 147 162 139 148 248 191 164 208 34 198 131 227 126 188 187
247 184 123 7 120 91 53 166 24 254 73 64 81 77 61 147 76 8 249 194
170 16 120 133 31 65 12 33 142 136 200 12 45 149 93 204 193 117 124
221 195 195 215 187 24 207 114 63 247 231 24 144 139 6 3 60 2 241
28 211 116 147 120 131 120 102 211 212 56 239 19 135 89 69 148 137
207 137 39 116 186 32 241 35 215 37 135 223 56 151 109 246 242 204
176 158 203 204 19 135 137 133 114 15 75 61 204 42 186 66 60 77 28
149 21 149 242 189 121 135 101 206 91 156 149 90 131 117 238 201 95
24 42 170 43 89 174 211 28 69 18 75 72 33 13 1 18 26 168 162 6 19
49 90 85 82 12 100 104 63 225 226 31 177 253 105 114 73 228 170 130
145 99 1 117 40 16 109 63 248 31 252 238 214 40 77 197 157 164 80 2
232 123 177 172 143 49 32 176 11 180 155 150 245 125 108 89 237 19
192 247 12 92 169 93 127 189 5 204 126 146 222 236 106 209 35 96
112 27 184 184 238 106 210 30 112 185 3 68 158 52 81 23 109 201 71
211 91 42 1 239 103 244 77 5 96 248 22 232 95 115 122 235 236 227
244 1 200 81 87 203 55 192 193 33 48 94 166 236 117 151 119 7 123
123 251 247 76 167 191 31 144 123 114 179
22 1 136 163 = crc
11
12
13 0 0 0 9 = length: 9
14 112 72 89 115 = type: pHYs
15 0 0 46 35 0 0 46 35 1
16 120 165 63 118 = crc
```



```
18 0 0 0 7 = length: 7
19 116 73 77 69 = type: tIME
20 7 229 4 8 19 43 58
21 20 117 151 76 = crc
22
23 0 0 0 19 = length: 7
24 116 69 88 116 = type: tEXt
25 67 111 109 109 101 110 116 0 80 78 71 32 67 111 109 109 101 110 116
26 113 91 124 183 = crc
27
28 0 0 0 36 = length: 36
29 73 68 65 84 = type: IDAT
30 8 29 1 25 0 230 255 1 0 0 0 0 0 255 0 255 1 0 0 255 255 1 1 0 0 255
0 255 1 0 0 255 74 17 6 255
31 210 212 196 170 = crc
32
33 0 0 0 0 = length: 0
34 73 69 78 68 = type: IEND
35 174 66 96 130 = crc
```

Found the signature (@PNG-): 137 80 78 71 13 10 26 10

Chunk IHDR: 73 72 68 82

width: 0 0 0 8

height: 0 0 0 1

bit depth: 8

color type: 2 (Truecolor)

compression: 0

filter: 0

interlace: 0 (No interlace)

Chunk iCCP (Embedded ICC profile): 105 67 67 80

Profile Name: ICC profile

Compression Method: 0

Chunk pHYs (Physical pixel dimensions): 112 72 89 115

Chunk tIME (last image modification): 116 73 77 69

year: 7 229 = 2021

month: 4

day: 8

hour: 19

min: 43

sec: 58

Chunk tEXt (Textual data): 116 69 88 116

Keyword: Comment

Text: PNG Comment

Chunk IDAT (Image data): 73 68 65 84

data: [8, 29, 1, 25, 0, 230, 255, 1, 0, 0, 0, 0, 0, 255, 255, 1, 0, 0, 255, 255, 1, 1, 0, 0, 255, 255, 74, 17, 6, 255]

Chunk IEND: 73 69 78 68

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```
data: [8, 29, 1, 25, 0, 230, 255, 1, 0, 0, 0, 0, 0, 255, 0, 255, 1, 0, 0, 255, 255, 1, 1, 0, 0, 255, 0, 255, 1, 0, 0,  
255, 74, 17, 6, 255]  
compressed data:↵0↓ EEO      E EO   EEOO    E EO   EJ←▲E  
uncompressed data (decimal): 1 0 0 0 0 0 255 0 255 1 0 0 255 255 1 1 0 0 255 0 255 1 0 0 255  
uncompressed data:           0       E EO   EEOO    E EO   E
```

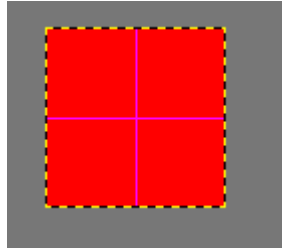
- Can use Zlib to decompress (inflate) the data from the IDAT chunk
- How to use decompressed data to reconstruct the image?
- Scanline filter first byte per row: 0 - actual value "None", 1 - add to left pixel "Sub", 2 - add to above pixel "Up"
 - Scanline size determined by width value in IHDR (times 3 for RGB)
 - Add 1 to 255 to roll over back to 0

1 0 0 0 0 0 255 0 255 1 0 0 255 255 1 1 0 0 255 0 255 1 0 0 255

1 - Scanline value (Sub)			
0	0	0 - black pixel	(0, 0, 0)
0	0	255 - blue pixel	(0, 0, 255)
0	255	1 - green pixel	(0, 255, 0)
0	0	255 - cyan pixel	(0, 255, 255)
255	1	1 - red pixel	(255, 0, 0)
0	0	255 - magenta pixel	(255, 0, 255)
0	255	1 - yellow pixel	(255, 255, 0)
0	0	255 - white pixel	(255, 255, 255)

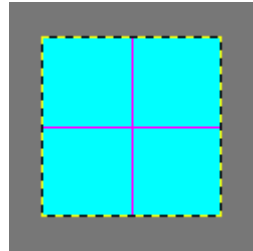
The logo for Knox Game Design features the word "KNOX" in red, "GAME" in green, and "DESIGN" in blue, all in a pixelated, blocky font. The text is arranged in three lines, with "DESIGN" being slightly larger and more prominent than the other two words.

More PNG IDAT Chunk examples



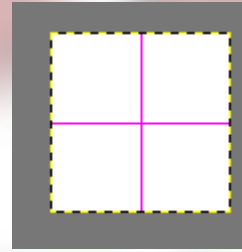
2x2 red

1	255	0	0	0	0	0
2	0	0	0	0	0	0



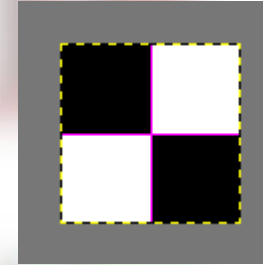
2x2 cyan

1	0	255	255	0	0	0
2	0	0	0	0	0	0



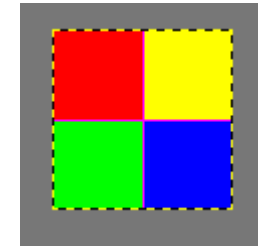
2x2 white

1	255	255	255	0	0	0
2	0	0	0	0	0	0



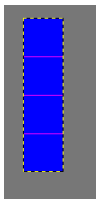
2x2 black, white

0	0	0	0	255	255	255
0	255	255	255	0	0	0



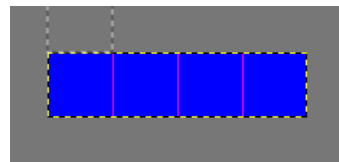
2x2 r,y,g,b

1	255	0	0	0	255	0
0	0	255	0	0	0	255



1x4 blue

0	0	0	255
2	0	0	0
2	0	0	0
2	0	0	0



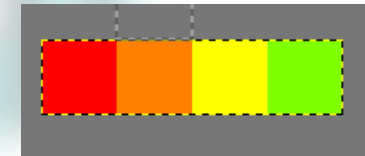
4x1 blue

1	0	0	255	0	0	0	0	0	0	0	0
---	---	---	-----	---	---	---	---	---	---	---	---



1x4 royg

0	255	0	0
2	0	128	0
0	255	255	0
2	129	0	0



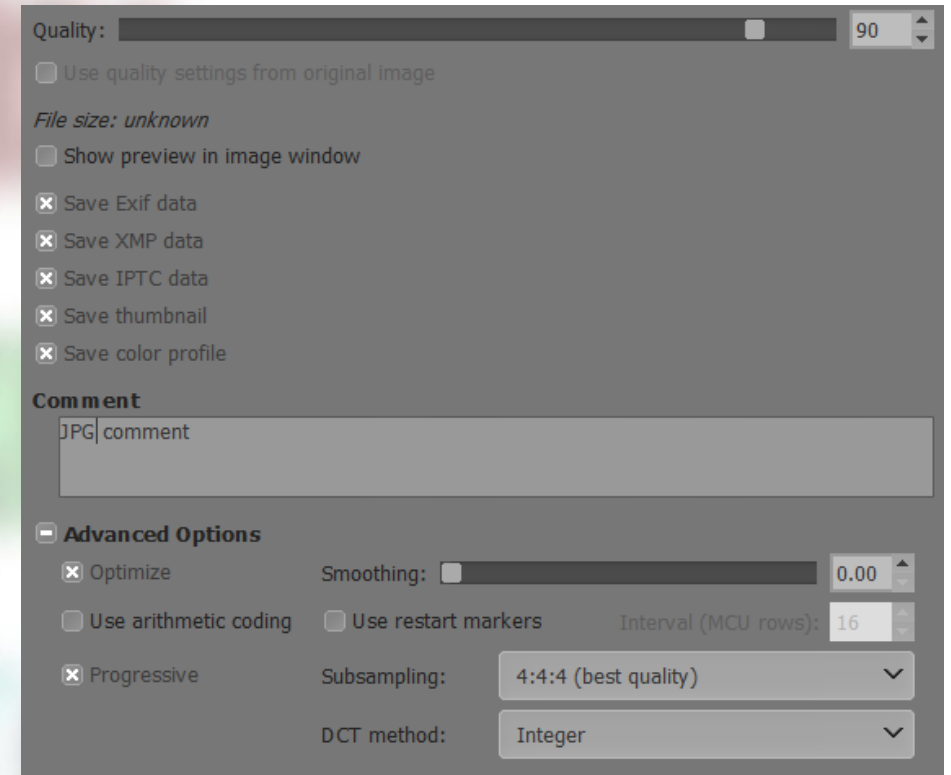
4x1 royg

0	255	0	0	255	128	0	255	255	0	128	255	0
---	-----	---	---	-----	-----	---	-----	-----	---	-----	-----	---

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JPEG

- Joint Photographic Experts Group
- Developed in 1992 by Joint Photographic Experts Group committee
- Lossy compression
- Specification
 - ISO/IEC 10918 (~\$200)
 - jpeg.org



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JPEG Quality Comparison

Image dimensions: 1024x768



Quality: 90
472 KB



Quality: 60
227 KB



Quality: 30
138 KB



Quality: 0
19 KB

Zoom: 400%



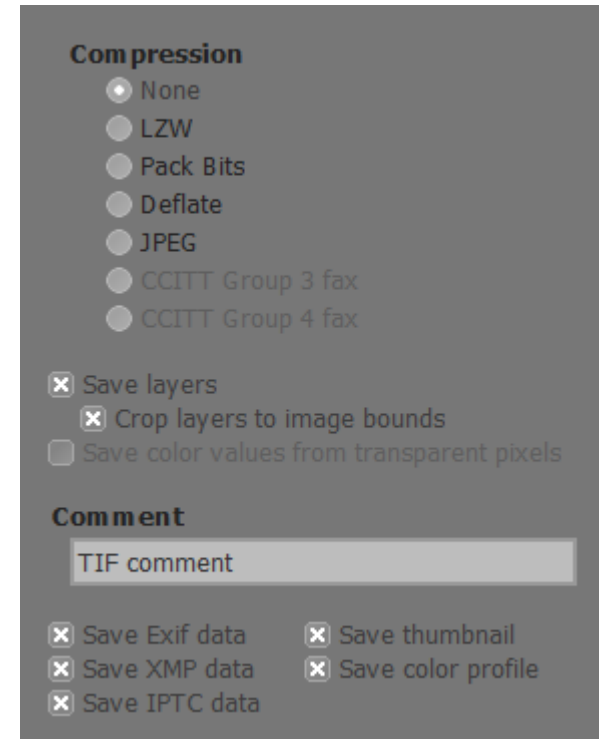
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SVG

- Scalable Vector Graphics
- Developed by W3C (World Wide Web Consortium), 2001
- Vector graphics, Lossless
- Specification
 - <https://www.w3.org/Graphics/SVG/>

TIFF

- Tag Image File Format
- Developed by Aldus Corporation, 1986
- Scanner data
- Specification
 - <https://www.adobe.io/open/standards/TIFF.html>



A screenshot of a software dialog box for saving a TIFF file. The dialog has a dark gray background and contains several sections of options. The 'Compression' section at the top has radio buttons for 'None' (selected), 'LZW', 'Pack Bits', 'Deflate', 'JPEG', 'CCITT Group 3 fax', and 'CCITT Group 4 fax'. Below this, there are three checkboxes: 'Save layers' (checked), 'Crop layers to image bounds' (checked), and 'Save color values from transparent pixels' (unchecked). The 'Comment' section features a text input field with the placeholder text 'TIF comment'. At the bottom, there are six checkboxes arranged in two columns: 'Save Exif data' (checked), 'Save XMP data' (checked), 'Save IPTC data' (checked) in the left column, and 'Save thumbnail' (checked), 'Save color profile' (checked) in the right column.

Compression

- ☒ None
- ☐ LZW
- ☐ Pack Bits
- ☐ Deflate
- ☐ JPEG
- ☐ CCITT Group 3 fax
- ☐ CCITT Group 4 fax

☒ Save layers

☒ Crop layers to image bounds

☐ Save color values from transparent pixels

Comment

TIF comment

☒ Save Exif data ☒ Save thumbnail

☒ Save XMP data ☒ Save color profile

☒ Save IPTC data

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TGA

- TARGA (Truevision TGA)
- Created by AT&T EPICenter / Truevision, 1984
- Specification
 - <https://docs.fileformat.com/image/tga/>
- Supported by Allegro 4
- Also used for textures



PCX

- PiCture eXchange
- Created by ZSoft Corporation, 1985
- Supported by Allegro 4

HEIC

- High Efficiency Image File Format
- Created by Moving Picture Experts Group, 2015
- HEIC - High Efficiency Video Coding
 - Format for Apple / iOS images

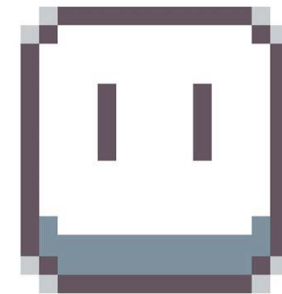
WebP

- Developed by google
- Lossless and lossy
- Transparency
- Animations
- Encoder/Decoder -
<https://developers.google.com/speed/webp/download>

Tools



- Bitmaps
 - Gimp (export to most formats)
 - Aseprite (BMP, FLC, FLI, GIF, ICO, JPEG, PCX, PCC, PNG, SVG, TGA, WebP)
 - MS Paint (BMP, JPEG, GIF, TIFF, PNG)
- Vector Graphics
 - Inkscape (SVG)



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Engine Support for Textures/Sprites

Format	Unity	Unreal Engine	Godot	GameMaker
BMP	Yes	Yes	Yes	Yes
GIF	Yes	No	No	Yes
JPG	Yes	Yes	Yes	Yes
PCX	No	Yes	No	No
PNG	Yes	Yes	Yes	Yes
TGA	Yes	Yes	Yes	No
TIFF	Yes	Yes	No	Yes

Note - TIFF must be named TIF (only one F) to import into Unreal Engine

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Engine Support

Unity

- BMP
- EXR
- GIF
- HDR
- IFF
- JPG
- PICT
- PNG
- PSD
- TGA
- TIFF

Unreal Engine

Texture (*.bmp)
Texture (*.float)
Texture (*.jpeg)
Texture (*.jpg)
Texture (*.pcx)
Texture (*.png)
Texture (*.psd)
Texture (*.tga)
Texture (Cubemap or 2D) (*.dds)
Texture (HDR) (*.exr)
Texture (TIFF) (*.tif)

Godot

- ATLASTEX (*.atlastex)
- BMP (*.bmp)
- CURVETEX (*.curvetex)
- DDS (*.dds)
- EXR (*.exr)
- HDR (*.hdr)
- JPEG (*.jpeg)
- JPG (*.jpg)
- LARGETEX (*.largetex)
- MESHTEX (*.meshtex)
- PKM (*.pkm)
- PNG (*.png)
- PVR (*.pvr)
- RES (*.res)
- SVG (*.svg)
- SVGZ (*.svgz)
- TEX (*.tex)
- TGA (*.tga)
- TRES (*.tres)
- WEBP (*.webp)

GameMaker

Image Files (*.png;*.gif;*.jpg;*.jpeg;*.tiff;*.ico;*.tif;*.bmp;*.2bp;*.mdi)

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References

- Image File Formats - <https://products.softsolutionslimited.com/blog/image-file-formats-what-is-an-image-file/>
- FileFormat Info - <https://www.fileformat.info>
- PNG History - <http://libpng.org/pub/png/book/chapter07.html>
- Image Formats - <https://www.gimp.org/tutorials/ImageFormats/>
- zlib compression - <https://www.ietf.org/rfc/rfc1950.txt>