Computers Graphics 電腦圖像

- Computers CANNOT store and transmit graphics using character representation codes such as ASCII. ('@'=64,'A'=65,'B'=66,...)
- 不能利用文字編碼 ASCII，來存儲或傳送圖像
- Computers must somehow encode (編碼) graphics as 1s and 0s to store them electronically. 以電子(數碼化)方式(0/1)來存儲圖像

Bitmap Graphics 點陣圖 (bmp, gif, jpg)

- x.bmp, x.gif, x.jpg 點陣圖的格式檔 are all bitmap graphical format data files.
- Computers store 存儲 bitmap graphics using a code(代碼) that indicates 表示 the state 狀態 (on=1 & off=0) of each individual 個別 dot (pixel 像素), displayed on the screen. 利用代碼(0101...) 去表示屏幕上的每一點/像素

http://www.cs.cf.ac.uk/Dave/Multimedia/node165.html

A 640 x 480 __(a)__ image 圖像 requires 需要 __(b)__ of storage 儲存空間

(a) 圖像 image	(b) 圖像大小 size	
黑白 1-bit Monochrome	KB	(640×480 pixels 像素/點)
灰階 8-bit gray-scale	KB	(640×480×8 bits)
彩色 8-bit color	307.2 KB	(+color lookup table)
真實色 24-bit true color	921.6 KB	(307.2×3)

http://gcsecomputing.org.uk/theory/1_4/1_4_images.html

colour depth (n-bit) 色深	Number (2^n) of possible colours 多少種不同顏色	Example binary code(s) used to store the colour information about each pixel
1-bit	$2^1=2$	0, 1
2-bit	$2^2=4$	00, 01, 10, 11
3-bit	$2^3=8$	000, 001, ..., 111
4-bit	$2^4=$	0000, 0001, ..., 1110, 1111
8-bit	$2^8=$	10010101, 11101101 ...
24-bit	$2^{24}=16,777,216$	010110101110001101001101

色深=用 n-bit 去表示 1 像素 pixel

CPU, memory & Binary Logic

- http://gcsecomputing.org.uk/theory/1_2/1_2_binary_logic.html

The simplest bitmap graphics are monochrome(單色:色深=1).最簡單的點陣圖

Example: figure 1

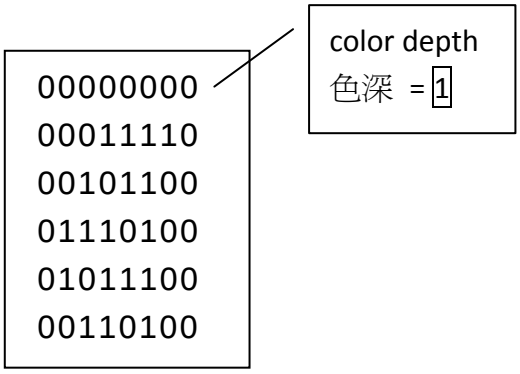
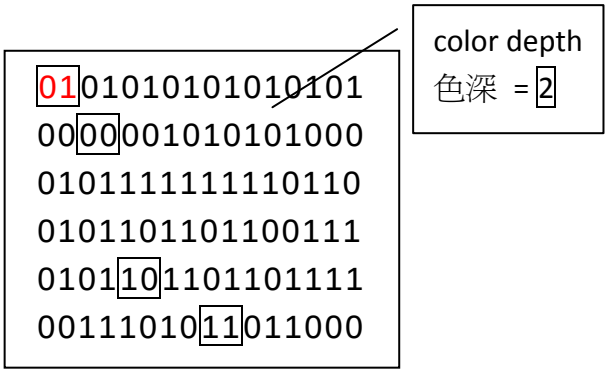


figure 2



- Each cell(pixel 每 1 像素) represents 代表 a light bulb 燈泡, 0 is off, 1 is on
- The dimensions of figure 1 is 8×8 pixels 尺寸大小爲 8×8 像素
- Its file size 圖檔大小 is ___ bits or ___ bytes (1 byte 字節 = 8 bits 位元)

Grey-scale 灰階 / Color 彩色 Bitmap Graphics 點陣圖

If each cell(pixel 像素) in figure 1 contains two light bulbs of different colors 每 1 像素包含 2 個不同顏色燈泡, figure 1 will have 4 colors 代表 4 種不同顏色

燈泡 1 \ 燈泡 2	0	1
0	**black 00**	**grey**
1	**grey**	**white**

- Then the file size of the color graphic 彩色點陣圖 圖檔大小 is _____ bits.
- The color depth of the graphic is two. 色深=2, 即以 2 bit 去代表每一_____
- (i.e. 2 bits are used to represent the color of a single dot/pixel)

Exercise

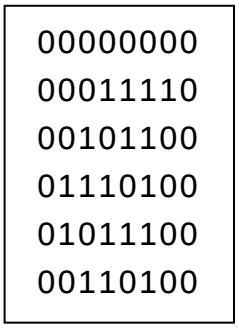
Use paint-brush 小畫家 to create a 640×480 pixel bitmap graphic 點陣圖.
What is the file size 圖檔大小 (in Byte) of that graphic?

		color depth 色深	File size (Bytes) 圖檔大小 (字節)
(a)	black and white	1	640×480
(b)	8-bit 256-color	8	640×480
(c)	24-bit true color	24	640×480

What is the color depth of the 256-color bitmap graphic (256 色)點陣圖, 色深=?

Resolution 解像度

- It is measured by dots per inch (dpi) 每英吋多少像素. If the actual size 實際大小 of figure 1 is one inch by one inch
- 1 吋×1 吋, its resolution 解像度 is then 8 dpi. 每英吋__
- In general, screen resolution 解像度 is 72 to ___ dpi,
- normal printing 一般印刷 is ____ dpi. (每 1 吋有 300 點)



Exercise

The actual size of a picture is 4 inches × 3 inches (實際大小: 4 吋×3 吋). If the screen resolution 屏幕解像度 is 96 dpi, what are the dimensions 該圖在屏幕上尺寸大小 of the graphic on the screen?

Compression 壓縮 of bitmap graphics 點陣圖

http://www.cs.cf.ac.uk/Dave/Multimedia/node171.html

1. JPG (Joint Photographic Experts Group):
   - Lossy 失真/不可還原(破壞性) compression 壓縮
   - (higher compression ratio means poorer quality
   - 壓縮比率(%)越高，圖像_____越低).
   - Support 24-bit true colors 真實色, suitable for photos. 適合儲存__
2. GIF (Graphics Interchange Format):
   - Lossless 非失真 compression (can retain 保留 original quality 原來質素).
   - Support _____ colors (8-bit), suitable for drawings, 適合__
   - Support 支援 transparency 透明 and animation 動畫.
3. BMP:
   - No compression 沒壓縮, huge file size 佔_____儲存空間
4. TIFF:
   - Lossless 非失真/可還原 compression
5. Postscript:
   - A typesetting programming language which includes text as well as vector/structured graphics and bit-mapped images
   - Used in several popular graphics programs (Illustrator, FreeHand)
   - No compression, files are often large

Useful links: http://www.why-not.com/articles/formats.htm
http://www.faqs.org/faqs/jpeg-faq/part1/

Compression 壓縮方法:

1. Lossless 非失真 compression

For Example: 894 00000 00000 00000 00000 00000 00000 00

we can replace with 取而代之 894 where f is the flag for zero.

- **Suppression** 壓抑 of **zero**'s in a file (Zero Length Suppression)

  Applications 應用 of this simple compression 壓縮方法 technique include:

  - 聲音：Silence 靜音 in audio data, Pauses 停頓 in conversation 對話
  - 圖像：Bitmaps 點陣圖
  - 文字：Blanks 空白 in text 文字檔 or program source files
  - 背景：Backgrounds in images 圖像背景

- **Run-length encoding**

  - frequently applied to images. 常用於圖像
  - a small compression component 壓縮組件 used in JPEG.

  For example:

  Original Sequence 壓縮前: 11112223333311112222

  can be encoded as 壓縮後: (1,),(2,),(3,),(1,),(2,)

  The savings are dependent on the data. 是否節省空間? 有時會不減反加!

  In the worst case (Random Noise) encoding is heavier than original file.

  e.g. 123456789... 最壞情況：沒有重複

- **Pattern Substitution** 文字取代

  This is a simple form of statistical encoding 簡單統計編碼.

  Here we substitute a frequently repeating 重複 pattern(s) with a code. 以代碼取代特定模式(pattern)的重複文字 The code is shorter than the pattern giving us compression. 代碼會比該組重複文字爲短

  A simple Pattern Substitution scheme could employ predefined code (for example, replace all occurrences of 'The' with the code '&').

  More typically tokens 代碼 are assigned to according to frequency of occurrence 出現頻次 of patterns:

  - Count occurrence of tokens (數算)
  - Sort in Descending order (排序)
  - Assign some symbols (符號) to highest count tokens

  A predefined symbol table may used (i.e. assign code *i* to token *i*).

  However, it is more usual to dynamically assign codes to tokens.

  The entropy encoding schemes below basically attempt to decide the optimum assignment of codes to achieve the best compression.

  http://en.wikipedia.org/wiki/Lossy_compression

"lossy" 失真 **compression** 壓縮
is a data encoding method that compresses data by discarding (losing) some of it.
捨棄部分資料

Compression ratio 壓縮比率

- Video 視像 can be compressed greatly (e.g. 100:1)
  with little visible 些微可見(察覺)質素損失 quality loss
- Audio 聲音 can often be compressed at 10:1 with little loss of quality
- Still images 靜態圖像 are often compressed at 10:1,
  but the quality loss is more noticeable 可察覺失真.

Most compression programs use a variation of the **LZ (Lempel and Ziv) adaptive dictionary-based algorithm** to shrink files 縮小檔案.

Dictionary	Text
1. **ask** 2. **what** 3. **your** 4. **country** 5. **can** 6. **do** 7. **for** 8. **you**	*"Ask not what your country can do for you –* *ask what you can do for your country."* *by John F. Kennedy 1961* Becomes : "**1 not 2 3 4 5 6 7 8 -- 1 2 8 5 6 7 3 4**"

we need to **save the dictionary** 字典也一起儲存 **itself along with the file**.

1. **ask_** 2. **what_** 3. **you** 4. **r_country** 5. **_can_do_for_you**	*"Ask not what your country can do for you –* *ask what you can do for your country."* *by John F. Kennedy 1961* Becomes : "**1not__2345__--__12354**"

Shockwave (swf)

- provides a **vector-based** 向量動畫 animation capability.
- Instead of specifying the color of every pixel, a Shockwave file specifies the coordinates of shapes (e.g. lines, rectangles, circles, etc.) and color of each shape. 儲存圖形(線,長方,圓)座標,顏色,____ (起點,終點,轉彎)
- Shockwave files can be extremely small. They allow animation and sound. The images are also scalable 支援動畫、聲音，可任意____.

5. Comparisons between BMP, GIF and JPEG file formats. 圖檔格式比較

	BMP	GIF	JPEG
File size 大小	大 Larger	小 Smaller	小 Smaller
Quality 質素 壓縮	Good 沒壓縮 No compression	Lossless 非失真 compression	Lossy 失真 compression
Color	24 bit colors	8 bit (256 colors)	24 bit colors
Transparency 透明	支援 Support	支援 Support	不支援 NO

6. Calculate the file size (in kB) of a 24-bit color 2048×1596 pixels 像素 bitmap 點陣圖 graphics. (1 Byte = 8 bits; 1 kB = 1024 Bytes)

File size =

7. If the graphics 2048×1596 pixels 像素 is printed out in 300 dpi (dots per inch), what will the length and width be (in inch)?

Length = Width =

Sound File Format 音效檔格式

1. WAV	● The raw recorded 原始錄製 digital sound 數碼音效, 沒有壓縮 uncompressed. ● e.g. from Windows build-in recorder 錄音機 (sndrec32.exe) ● file size (bit) = no. of channels 聲道 × sampling rate 取樣率 × sampling size 取樣大小 × recording time 收錄時間 (in second)
2. MP3	● MPEG-2 Audio Layer-3 ● most commonly used compressed digital audio 音效 file ● Lossy 失真/不可還原 compression 壓縮 (by remove those sound in inaudible regions). 棄置聽不到的部分 ● Compression ratio 壓縮比率 is usually ____ (with 128 kbps bit rate & 44.1 kHz sampling rate 取樣率, 16-bit 取樣大小)
3. MIDI	● Musical Instrument Digital Interface ● Music and sound are synthesized 合成 by sound card 音效咭 ● stores the codes (program) only, so very small file size 儲存_____，檔案體積____ ● MIDI software 編輯軟件 can generate or edit the MIDI codes

Exercise:

1. Using Window Sound Recorder to record above 30 seconds of your voice and then take down the following data:

Recording time in second:	
File size in byte:	
Sampling Rate:	
Sampling Size:	
Mono or stereo?	

2. Calculate the file size (30 秒) and show the steps

file size = sampling rate * sampling size * time * no. of channels

44.1 kHz × 16 bit × t × 2

= 44.1 × 1000 × 16 × 30 × 2 bits (1 k = 1000)

= 44.1 × 1000 × 2 × 30 × 2 Bytes

= _____ (30) Bytes

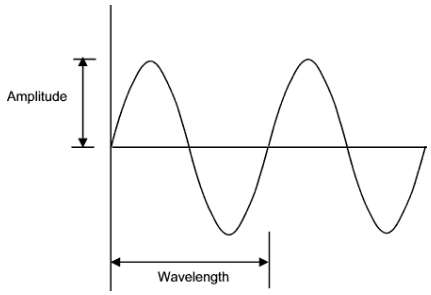
= _____

3. Change your sound file from WAV format to MP3 and take down the file size.

4. Using Anvil Studio to create a 30 second music and save your song as MID format. Take down the file size.

Sound

Sound is a wave pattern, characterized by loudness (amplitude) and pitch (frequency) http://www.phy.ntnu.edu.tw/ntnujava/index.php?board=3.0

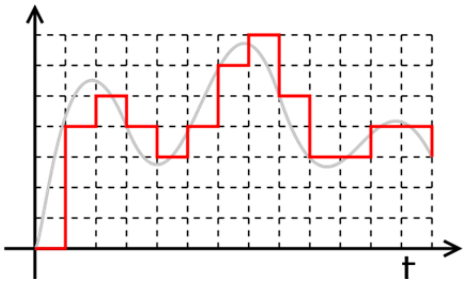


Frequency: The no. of times the wavelength occurs in one second.
Measured in kilohertz (kHz).

Digital audio

Digitization 數碼化 of sound:

Analogue 模擬 sound wave --> digital 數碼 (01001) values



Advantage : Computer can handle.
Disadvantage : Cause distortion 失真.

CD-quality (44,100 times/sec, 2-byte)

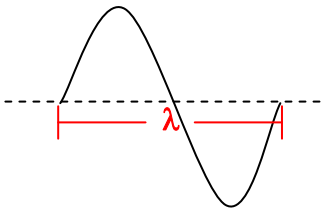
1 second of music(stereo) requires: 1 秒 (立體聲) 音樂 44,100 = 176,400 bytes / sec	3-minute song = 176,400(3)(60) = 31,752,000 bytes =

MP3 Bit Rates

the number of bits per second encoded in the MP3 file
The lower the bit rate, the more information the encoder will discard when compressing the file.
Bit rates range from 96 to 320 Kbps (kilobytes per second).
Using a bit rate of 128 Kbps usually results in a sound quality equivalent to what you'd hear on the radio.
use a bit rate of 160 Kbps or higher the MP3 file will sound like CD quality

http://www.cs.cf.ac.uk/Dave/Multimedia/node143.html

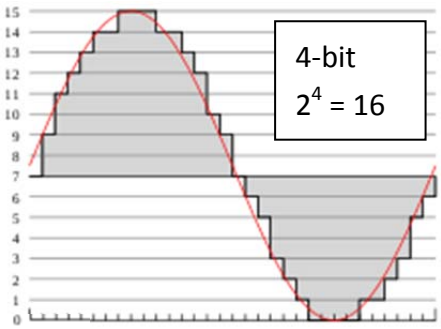
Electronic Music
http://www.indiana.edu/~emusic/etext/toc.shtml



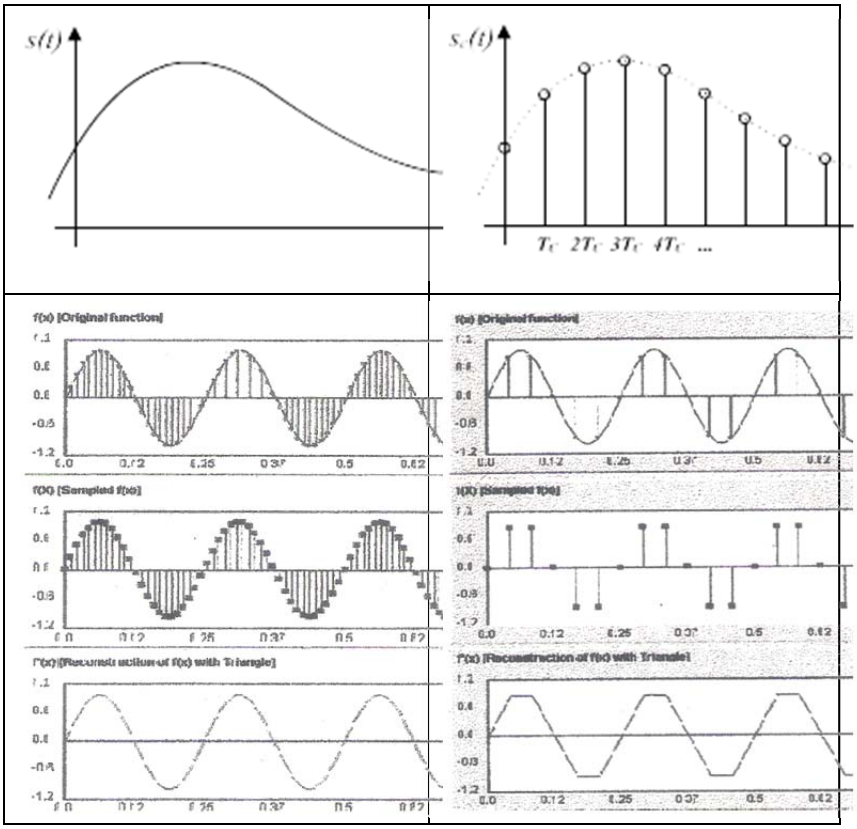
frequency 音頻 → sound pitch 音高 (rapid oscillation 振盪)
(單位 Hertz = cycles per sec 循環/秒 = no.of wavelengths λ/sec)
amplitude 幅度 (height 高度) → intensity 强度 (decibel 分貝) → loudness 聲量大小

Sampling 取樣本 (數碼化)

- records the height of the sound wave at **regular time intervals** T_i
- 每隔一定時間 T_i，記錄高度
- **file size** (bit) = no. of channels 聲道 × sampling rate 取樣率 × sampling size 取樣大小 × recording time 收錄時間 (秒)
- **Sampling rate** 取樣率 is the number of times that the sound wave is measured in each second. (e.g. 44.1 kHz) 每秒取樣(量度)次數 (44,100 次)
- **Sampling size** 取樣大小 is the number of bits used to store the height (amplitude) of the sound wave (e.g. 16 bits). 高度細分程度 2^{16} =



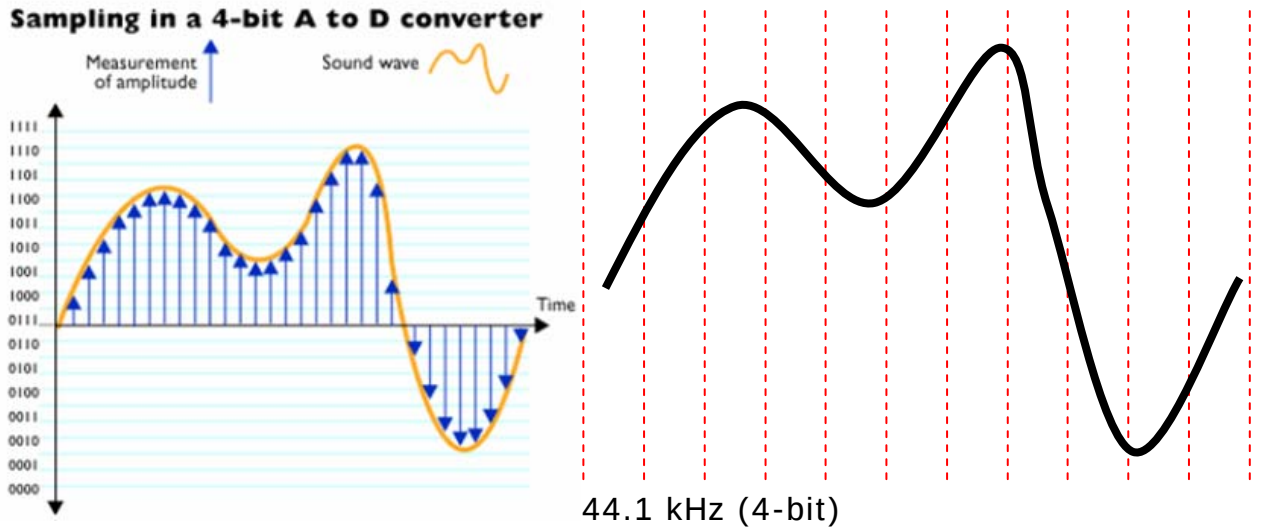
記錄高度



* Low sample rate 取樣率太低, may cause the output wave clipping 剪裁

Standards:

1. Sampling Rate 取樣率	2. Sampling Size 取樣大小	3. Channels 聲道
08.0 kHz Telephone	08-bit：Spoken voice	1-mono
11.1 kHz Spoken voice	08-bit：AM radio	2-stero
22.05 kHz AM radio	16-bit：CD-Audio	
44.1 kHz CD-Audio	24-bit：Professional	



mp3 壓縮方式 http://www.fashionguide.com.tw/MsgL/07/3_TopicL_139548_1.html

音樂 CD 的流量是每秒 44100*16*2 =1411200bps =1411.2kbps，而我們常用的 MP3 流量只有 128kbps，壓縮後的容量小於原先的十分之一，而聽起來聲音卻還不錯。MP3 壓縮時運用到五個重要的技巧，分別是

- 最小聽覺門檻判定(The minimal audition threshold)，

是一種減少資料量的手段，因爲人耳對不同頻率的聲音聽到的音量反應不是平直的，因此我們可以將大部分的紀錄資訊集中在人耳最靈敏的 2kHz 到 5kHz，其餘頻率分配比較少的容量紀錄。

- 遮蔽效應(The Masking effect)，

也是聽覺心理學模型(Psychoacoustic models)的一種，在視覺上呈現的效果是在大太陽下比較難看到天空中飛翔的鳥，聽覺上的涵義就是當有一個音量或音色特別突出的聲音出現，其他細小的聲音會比較難被察覺，就像是管絃樂團齊奏時不易發現觀眾的咳嗽聲，儘管咳嗽的音量與沒有其他聲音時其實是相同的。因此在編碼時我們不需要把所有的聲音細節都編進去，而該把資料拿去紀錄比較突出容易引起注意的聲音。

- 位元儲存槽(The reservoir of bytes)，

在解釋前要先說明 MP3 的流量屬性，CBR 和 VBR。

CBR 是 Constant Bitrate 的縮寫，也就是說該 MP3 每秒鐘的資料流量是固定的，常見的 MP3 都是以 CBR 編碼，好處是壓縮速度快。

VBR 是 Variable Bitrate 的縮寫，每秒鐘的流量是可以變化的，好處是在訊號複雜時用比較多的容量去紀錄，波型簡單時就用比較低的流量，以有效利用空間。

CBR 的缺點就是每秒鐘的流量都相同，很容易造成空間的浪費，因此有 reservoir of bytes 的出現，用途是當波型簡單時不要用那麼大的流量，把多餘的空間保留下來儲存將來比較複雜的波性資料，維持流量的大小，達到類似 VBR 的效果。VBR 的 MP3 並不需要 reservoir of bytes。

- The Joint Stereo

是一種立體聲編碼技巧，主要分爲 Intensity Stereo(IS)和 Mid/Side (M/S) stereo 兩種。IS 的是在比較低流量時使用，利用了人耳對於高頻訊號向位分辨能力的不足，將音訊資料中的低頻分解出來合成單聲道資料，剩餘的高頻資料則合成另一個單聲道資料，並另外紀錄高頻資料的位置資訊，來重建立體聲的效果。例如鋼琴獨奏的錄音就可以利用這種方法在有限的資料流量中減少音場資訊但大幅增加音色資訊。

Mid/Side (M/S) stereo

在左右聲道資料相似度大時常被用到，紀錄方式是將左右聲道音訊合併(L+R)得到新的一軌，再將左右聲道音訊相減(L-R)得到另外一軌，然後再將這兩軌資料用上面提到聽覺心理學模型與濾波器處理。Mid/Side (M/S) stereo 與 IS 一樣的是利用部分相位(phase)資訊的損失來換得較高的音色紀錄資訊。一般的 MP3 是 Mid/Side stereo 和 Intensity Stereo 交替使用的，視資料內容與流量而定。如果是更高流量如 160kbps 以上的 MP3，則可以單獨將立體聲的兩個聲道獨立編碼，以保存相位資訊。

- Huffman 編碼 (coding)

是一種常見的無失真壓縮方案。當 PCM 訊號被分成好幾個頻段，並經過以上的處理之後，最後經過 MDCT(Modified Discrete Cosine Transform) (類似 FFT(Fast Fourier Transforms))，將波型轉換爲一連串的系數。這些系數最後經過 Huffman 編碼來做最後的壓縮。Huffman 編碼的原理是將比較常出現的字串用特定的符號表示，壓縮後就得到一個紀錄每個符號代表的字串的編碼表，以及一連串由各符號組成的資料內容。Huffman 編碼可以節省約 20%的空間，而也因爲經過了 Huffman 編碼，我們可以發現用 WinZip、WinRAR 之類的壓縮軟體並沒有辦法把 MP3 檔縮小多少，理由就是因爲這些壓縮軟體，也是利用類似 Huffman 編碼的技巧，因此壓縮程度有限。以上關於 MP3 編碼的資料取自 http://www.mp3-tech.org/tech.html。

MP3 播放時的運算遠比編碼時簡單，只要先經過 Huffman 解碼再由 MDTC 的逆運算重建波型就可以了，值得注意的是 MP3 不同於 PCM 沒有振幅紀錄精度(bits)的概念，我們可以自由使用 16bits 或是 20bits 甚至 24bits 的運算精度來重建波型。一般的 MP3 Player 運算精度都是 16bits，而 Winamp 的 MP3 解碼外掛 MAD(作者網頁 http://www.mars.org/home/rob/proj/mpeg/mad-plugin/) 則是以 24bits 處理，如果使用的音效卡支援 24bits 格式的 PCM，就可以直接輸出 24bits 的訊號。一般的娛樂用音效卡都只有 16bits 數類轉換能力，因此訊號送給音效卡前必須要先經過 re-dithering 的過程，我們從之前的介紹可以知道經過這樣的處理可以聽到比 16bits 更多的聲音資訊與動態範圍，因此 MAD 在一般的音效卡上仍有其使用價值。筆者使用 MAD 與 Winamp 2.74 內建的 MP3 decoder 比較，發現 MAD 音質的確比較好，聲音開闊，小提琴擦弦感與鋼琴力度都比內建 decoder 好很多，強烈建議各位聽 MP3 時搭配使用

Definition of Digital 數碼 –

A method of storing, processing and transmitting information through the use of distinct electronic or optical pulses that represent the binary digits 0 and 1.

Advantages of Digital -	Disadvantages of Digital -
● Less expensive ● More reliable ● Easy to manipulate ● Flexible ● Compatibility with other digital systems ● Only digitised information can be transported through a noisy channel without degradation ● Integrated networks	● Sampling Error ● Digital communications require greater bandwidth than analogue to transmit the same information. ● The detection of digital signals requires the communications system to be synchronised, whereas generally speaking this is not the case with analogue systems.

Definition of Analogue 模擬 -

Analogue is a transmission standard that uses electrical impulses to emulate the audio waveform of sound. When you use a phone, the variations in your voice are transformed by a microphone into similar variations in an electrical signal and carried down the line to the exchange.

Advantages of Analogue -	Disadvantages of Analogue -
● Uses less bandwidth ● More accurate	● The effects of random noise can make signal loss and distortion impossible to recover ● No error checking mechanism

http://cnx.org/content/m11060/latest/

VCD: 352×240

DVD: 720×480