

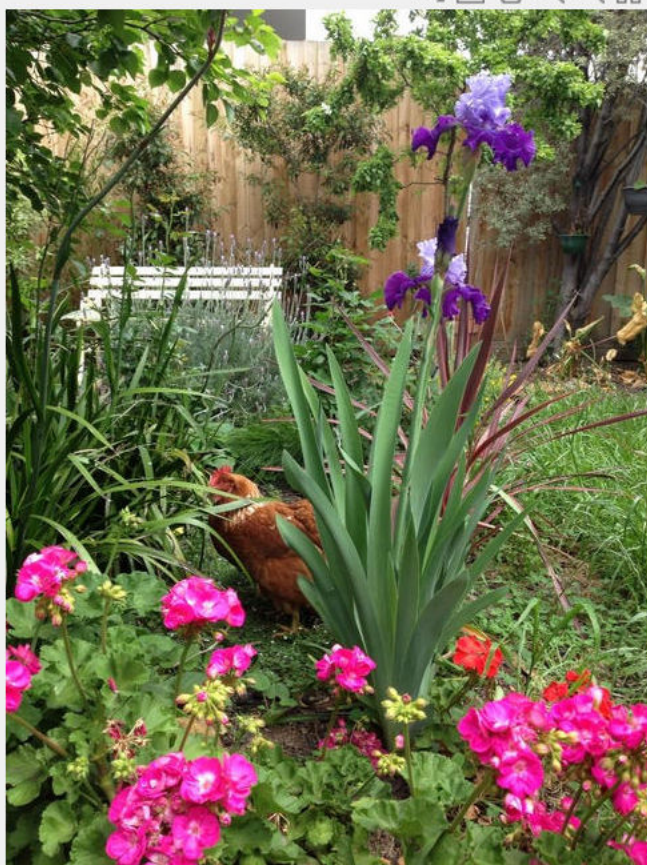
讀取影像

```
img = imread("D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\backyard.png");  
size(img)
```

```
ans =  
    643    482     3
```

讀進來的影像是一個三維矩陣，高 643、寬 482，然後有三個色彩的 channel

```
figure;  
imshow(img);  
impixelinfo;
```



Pixel info: (258, 216) [161 187 160]

show 出圖片，**impixelinfo** 可以讓滑鼠游標顯示出圖的 info，往右走是 X，往下走是 Y

```
img_gray = rgb2gray(img);  
imshow(img_gray);
```



用 *rgb2gray* 可以把彩色的圖片轉成黑白的

Bit Depth

```
imfinfo("D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\backyard.png")
```

```
ans = struct with fields:  
    Filename: 'D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\backyard.png'  
    FileModDate: '20-Sep-2022 13:45:01'  
    FileSize: 713173  
    Format: 'png'  
    FormatVersion: []  
    Width: 482  
    Height: 643  
    BitDepth: 24  
    ColorType: 'truecolor'  
    FormatSignature: [137 80 78 71 13 10 26 10]  
    Colormap: []  
    Histogram: []
```

```

        InterlaceType: 'none'
        Transparency: 'none'
SimpleTransparencyData: []
        BackgroundColor: [1 1 1]
        RenderingIntent: 'perceptual'
        Chromaticities: [293/937 329/1000 16/25 33/100 3/10 3/5 3/20 3/50]
            Gamma: 9091/20000
        XResolution: 72
        YResolution: 72
        ResolutionUnit: 'unknown'
            XOffset: []
            YOffset: []
            OffsetUnit: []
        SignificantBits: []
        ImageModTime: []
            Title: []
            Author: []
        Description: []
        Copyright: []
        CreationTime: []
        Software: []
        Disclaimer: []
        Warning: []
        Source: []
        Comment: []
        OtherText: {7x2 cell}

```

```
imfinfo("D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\binary_tools.png")
```

```
ans = struct with fields:
```

```

        Filename: 'D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\binary_tools.png'
        FileModDate: '20-Sep-2022 13:45:01'
        FileSize: 3100
        Format: 'png'
        FormatVersion: []
        Width: 433
        Height: 548
        BitDepth: 1
        ColorType: 'grayscale'
        FormatSignature: [137 80 78 71 13 10 26 10]
        Colormap: []
        Histogram: []
        InterlaceType: 'none'
        Transparency: 'none'
SimpleTransparencyData: []
        BackgroundColor: []
        RenderingIntent: []
        Chromaticities: []
            Gamma: []
        XResolution: []
        YResolution: []
        ResolutionUnit: []
            XOffset: []
            YOffset: []
            OffsetUnit: []
        SignificantBits: []
        ImageModTime: []
            Title: []
            Author: []
        Description: []
        Copyright: []
        CreationTime: []
        Software: []
        Disclaimer: []

```

```
Warning: []
Source: []
Comment: []
OtherText: []
```

```
imfinfo('D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\emu.png')
```

```
ans = struct with fields:
    Filename: 'D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\emu.png'
    FileModDate: '20-Sep-2022 13:45:02'
    FileSize: 71116
    Format: 'png'
    FormatVersion: []
    Width: 331
    Height: 384
    BitDepth: 8
    ColorType: 'indexed'
    FormatSignature: [137 80 78 71 13 10 26 10]
    Colormap: [64x3 double]
    Histogram: []
    InterlaceType: 'none'
    Transparency: 'none'
    SimpleTransparencyData: []
    BackgroundColor: []
    RenderingIntent: []
    Chromaticities: []
    Gamma: []
    XResolution: []
    YResolution: []
    ResolutionUnit: []
    XOffset: []
    YOffset: []
    OffsetUnit: []
    SignificantBits: []
    ImageModTime: []
    Title: []
    Author: []
    Description: []
    Copyright: []
    CreationTime: []
    Software: []
    Disclaimer: []
    Warning: []
    Source: []
    Comment: []
    OtherText: []
```

顏色小知識: 每一個 bit 可表示一種顏色, bit depth 就是用二進位表達一個 channel 有的顏色數量。bit depth = 8 表示一個 channel 有 2^8 個顏色。每個 channel 的 bit depth 被稱為 bits per channel (bpc), 把一個像素所有 channel 的 bit depth 加起來就是一個像素可以表達的顏色數量, 叫 bits per pixel (bpp)。

用 **imfinfo** 可以 show 出圖片的資訊, 這裡的 Bit Depth 是指 per channel 還是 per pixel 還不大確定, 但我猜應該是 per channel, 因為 true color 的 bit depth 是 24。colortype 有三種類型 [true color, grayscale, indexed]

Read Indexed Image

```
[img, img_index] = imread("D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\er
```

```
img = 384x331 uint8 matrix
```

```
17 23 17 23 25 23 25 26 26 35 43 35 16 6 9 12 21 30 28 23 23 23 23
33 35 43 43 43 35 26 33 35 43 43 35 23 10 6 7 12 20 30 23 26 23 23
23 25 23 23 25 43 50 43 35 36 35 35 26 6 6 6 10 12 25 30 26 23 23
16 10 16 16 23 43 35 26 15 6 6 6 16 15 16 6 6 10 12 26 35 28 26
26 33 43 43 35 23 6 6 6 6 6 6 16 6 16 6 6 6 10 12 23 30 35
35 37 43 26 6 6 16 5 16 16 6 6 6 6 6 6 6 6 7 12 17 28
35 26 14 23 15 15 15 15 15 26 36 23 16 6 6 10 6 6 2 4 9 12 23
35 26 26 23 23 38 36 22 14 10 14 38 35 15 6 26 33 10 10 2 2 12 9
15 35 26 22 16 36 55 30 5 5 15 26 49 22 10 9 49 15 15 23 4 4 7
30 35 46 25 15 17 53 30 15 5 14 15 38 56 38 37 38 49 27 41 47 2 4
10 35 32 46 28 22 38 22 14 5 14 7 14 53 38 30 20 22 46 47 54 24 3
15 18 35 49 26 36 30 14 14 5 5 5 14 14 30 36 17 26 38 44 30 12 7
30 7 12 55 24 11 22 15 14 5 5 5 5 14 14 46 36 22 33 41 39 32 10
40 41 18 40 41 11 11 30 15 7 5 5 5 14 36 36 36 36 10 38 41 22 9
31 40 40 40 24 9 7 22 14 7 5 5 5 14 27 27 14 50 22 35 38 28 9
31 24 40 40 19 4 7 11 12 14 5 5 5 14 14 14 14 15 35 26 35 37 28
18 24 24 24 21 2 4 7 7 11 5 14 5 14 14 14 15 23 15 15 23 30 32
19 11 24 24 11 11 7 13 24 30 14 5 14 5 5 5 16 16 23 10 16 23 18
11 11 19 13 7 11 40 24 32 32 11 7 5 5 14 5 6 6 6 33 17 7 10
18 11 21 11 13 11 40 49 18 22 14 15 5 5 5 15 15 6 6 35 55 30 17
31 7 11 40 19 2 13 9 12 12 19 22 22 14 14 5 15 6 3 12 56 32 26
26 11 7 11 7 7 19 11 11 2 18 22 27 38 14 14 16 6 12 1 56 38 28
15 2 5 2 2 2 7 13 11 7 19 24 22 22 27 22 22 27 22 1 49 47 12
38 5 2 2 2 7 9 11 7 7 21 49 11 11 36 11 22 40 49 18 22 46 12
49 14 5 2 5 7 11 18 12 7 7 24 24 29 53 19 19 22 56 40 2 22 7
14 7 5 2 5 7 12 22 11 12 4 12 24 46 49 29 24 24 40 49 4 7 12
14 5 2 2 2 2 5 7 7 11 12 12 12 18 24 18 19 32 56 31 9 4 18
22 5 5 2 2 2 2 7 7 11 23 22 30 12 30 38 32 31 56 49 18 9 24
27 7 5 2 2 5 7 7 4 7 12 22 43 60 36 36 38 36 31 49 22 18 32
49 27 2 7 7 2 7 7 4 7 7 17 30 56 46 36 53 46 50 49 32 18 30
57 49 7 7 7 7 7 4 7 7 13 16 26 27 22 14 14 30 38 60 24 19 18
49 57 24 7 7 7 4 2 7 9 31 12 17 35 36 38 35 32 22 32 24 18 11
54 57 57 13 11 7 4 4 4 4 24 20 23 27 44 47 54 54 54 18 11 11 11
57 57 57 40 11 9 2 4 7 7 9 12 12 12 39 39 41 48 57 49 19 11 11
63 61 49 40 31 13 4 2 4 13 7 7 12 23 18 34 29 54 49 31 11 11 13
57 61 57 21 57 24 1 9 11 11 13 12 12 22 17 28 41 54 49 18 19 19 4
```

```
:
```

```
img_index =
```

```
31/255      31/255      12/85
41/255      3/17       49/255
46/255     13/51      44/255
18/85      10/51       1/5
56/255     62/255     22/85
56/255     88/255     46/255
62/255     21/85      49/255
21/85      92/255     67/255
67/255     22/85      13/51
14/51      73/255      1/3
5/17       24/85       67/255
79/255     113/255     6/17
16/51      88/255     86/255
16/51      88/255    103/255
83/255     37/85      14/51
28/85      31/85      24/85
1/3        26/85      71/255
91/255     89/255     86/255
19/51      23/51      22/51
```

19/51	137/255	112/255
32/85	32/85	7/17
32/85	107/255	25/51
32/85	38/85	94/255
101/255	19/51	89/255
103/255	28/51	42/85
36/85	20/51	2/5
37/85	22/51	97/255
37/85	48/85	113/255
112/255	22/51	22/51
112/255	23/51	128/255
112/255	42/85	36/85
116/255	54/85	8/15
121/255	137/255	26/51
124/255	23/51	112/255
127/255	122/255	127/255
128/255	25/51	113/255
43/85	47/85	23/51
9/17	134/255	128/255
8/15	151/255	44/85
137/255	134/255	139/255
137/255	166/255	154/255
46/85	139/255	10/17
49/85	47/85	143/255
148/255	46/85	26/51
3/5	146/255	157/255
52/85	146/255	48/85
52/85	158/255	29/51
32/51	157/255	31/51
32/51	157/255	166/255
32/51	176/255	56/85
173/255	54/85	3/5
58/85	166/255	163/255
35/51	169/255	58/85
59/85	12/17	57/85
188/255	37/51	38/51
38/51	182/255	176/255
64/85	196/255	11/15
199/255	40/51	69/85
69/85	199/255	191/255
214/255	208/255	209/255
13/15	13/15	214/255
15/17	224/255	77/85
76/85	15/17	58/85
14/15	16/17	16/17

```
imshow(img, img_index)
```



```
imshow(img)
```



```
img_index
```

```
img_index =
  31/255    31/255    12/85
  41/255     3/17    49/255
  46/255    13/51    44/255
  18/85     10/51     1/5
  56/255    62/255    22/85
  56/255    88/255    46/255
  62/255    21/85    49/255
```

21/85	92/255	67/255
67/255	22/85	13/51
14/51	73/255	1/3
5/17	24/85	67/255
79/255	113/255	6/17
16/51	88/255	86/255
16/51	88/255	103/255
83/255	37/85	14/51
28/85	31/85	24/85
1/3	26/85	71/255
91/255	89/255	86/255
19/51	23/51	22/51
19/51	137/255	112/255
32/85	32/85	7/17
32/85	107/255	25/51
32/85	38/85	94/255
101/255	19/51	89/255
103/255	28/51	42/85
36/85	20/51	2/5
37/85	22/51	97/255
37/85	48/85	113/255
112/255	22/51	22/51
112/255	23/51	128/255
112/255	42/85	36/85
116/255	54/85	8/15
121/255	137/255	26/51
124/255	23/51	112/255
127/255	122/255	127/255
128/255	25/51	113/255
43/85	47/85	23/51
9/17	134/255	128/255
8/15	151/255	44/85
137/255	134/255	139/255
137/255	166/255	154/255
46/85	139/255	10/17
49/85	47/85	143/255
148/255	46/85	26/51
3/5	146/255	157/255
52/85	146/255	48/85
52/85	158/255	29/51
32/51	157/255	31/51
32/51	157/255	166/255
32/51	176/255	56/85
173/255	54/85	3/5
58/85	166/255	163/255
35/51	169/255	58/85
59/85	12/17	57/85
188/255	37/51	38/51
38/51	182/255	176/255
64/85	196/255	11/15
199/255	40/51	69/85
69/85	199/255	191/255
214/255	208/255	209/255
13/15	13/15	214/255
15/17	224/255	77/85
76/85	15/17	58/85
14/15	16/17	16/17

在讀取 indexed image 的時候, 要連 index 的 map 一起讀進來, show 的時候也要一起 show。如果沒有 map 的話會變黑白的, 原本的顏色會不見。index image 的 index 表每個 row 表示一個顏色, 分別為 RGB, range 從 0~1。

Double

```
img = imread("D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\caribou.jpg");  
img_double = double(img)
```

```
img_double =  
    167      172      161      147      146      144      145      155  
    165      170      164      150      140      136      138      145  
    160      163      164      155      139      135      140      142  
    156      153      158      155      144      146      152      146  
    159      152      155      156      151      157      159      149  
    166      163      163      161      159      160      157      149  
    157      166      168      162      157      150      145      146  
    137      158      165      156      147      135      131      141  
    147      147      151      153      147      139      140      148  
    157      156      153      150      150      152      154      154  
    143      145      143      139      142      147      141      130  
    156      156      152      148      149      149      143      135  
    160      149      138      133      130      129      134      141  
    159      147      138      138      138      136      140      147  
    149      140      134      139      148      150      142      135  
    ⋮  
    ⋮
```

img_double

```
img_double =  
    167      172      161      147      146      144      145      155  
    165      170      164      150      140      136      138      145  
    160      163      164      155      139      135      140      142  
    156      153      158      155      144      146      152      146  
    159      152      155      156      151      157      159      149  
    166      163      163      161      159      160      157      149  
    157      166      168      162      157      150      145      146  
    137      158      165      156      147      135      131      141  
    147      147      151      153      147      139      140      148  
    157      156      153      150      150      152      154      154  
    143      145      143      139      142      147      141      130  
    156      156      152      148      149      149      143      135  
    160      149      138      133      130      129      134      141  
    159      147      138      138      138      136      140      147  
    149      140      134      139      148      150      142      135  
    ⋮  
    ⋮
```

在 matlab 裡可以讀取 unit8 或者是 double 兩種數值的 grayscale picture, 可是如果是讀 double 的時候 range 要設成 0~1。上面那個圖原本是 uint8, 轉成 double 後因為沒有重新 scale, 所以值全部都大於 1, 跑出來的圖就會是全白。

```
img_d_255 = img_double / 255; imshow(img_d_255)
```



```
img_d_128 = img_double / 128; imshow(img_d_128)
```



```
img_d_512 = img_double / 512; imshow(img_d_512)
```



將 float 的 matrix 除以 255 就會變成原本的顏色，除以 128 就會比原來的白 2 倍，除以 512 就會比原來的黑 2 倍。

```
create_index_128 = img > 128; imshow(create_index_128)
```



```
create_index_64 = img > 64; imshow(create_index_64)
```



用這個方法可以直接創造出 binary image

Bit Plane

Bit Plane 就是把 grayscale picture 每個 pixel 的 bit 單獨拿出來畫成 8 張 binary image, 越右邊的 bit 越沒意義, 越左邊的 bit 可以把圖的輪廓畫出來。

```
img = imread("D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\cameraman.png");
```

```
img = 256x256 uint8 matrix
```

156	159	158	155	158	156	159	158	157	158	158	159	160	160	160	158	163	161	162
160	154	157	158	157	159	158	158	158	160	155	156	159	158	160	157	165	159	161
156	159	158	155	158	156	159	158	157	158	158	159	160	160	160	158	163	161	162
160	154	157	158	157	159	158	158	158	160	155	156	159	158	160	157	165	159	161
156	153	155	159	159	155	156	155	155	157	155	154	154	158	162	157	157	158	157
155	155	155	157	156	159	152	158	156	158	152	153	159	156	157	161	160	158	161
156	153	157	156	153	155	154	155	157	156	155	156	155	157	158	160	157	160	161
159	159	156	158	156	159	157	161	162	157	157	159	161	156	163	158	159	161	158
158	155	158	154	156	160	162	155	159	161	156	161	160	155	158	161	162	162	161
155	154	157	158	160	160	159	160	158	161	160	160	158	161	158	160	162	159	163
154	157	157	157	156	155	159	154	159	158	161	158	158	160	159	160	161	159	157
152	150	155	154	152	156	157	156	157	154	157	159	155	156	159	160	157	160	156
157	153	156	155	157	160	160	157	159	159	160	161	160	160	158	163	163	160	160
151	154	157	156	156	158	158	156	157	159	158	156	159	161	159	160	161	160	161
156	157	157	160	159	159	156	158	159	162	161	160	160	161	162	164	159	161	165
157	158	159	157	157	154	153	158	159	155	160	159	161	161	159	160	164	164	164
154	154	156	157	158	159	157	160	158	158	156	157	157	159	160	158	160	160	160
151	153	157	152	156	156	155	156	157	157	155	157	160	157	156	163	163	161	162
153	155	154	153	156	155	153	155	153	155	154	156	155	153	159	159	162	162	158
152	154	152	156	159	154	156	155	161	157	157	161	160	159	162	161	161	162	165
154	157	155	156	157	154	158	158	158	158	158	162	160	159	160	161	160	163	163
155	153	155	155	159	160	159	161	158	159	160	161	159	159	162	161	162	164	163
151	151	153	155	153	156	155	155	157	156	157	156	160	160	157	160	163	163	160
150	151	155	154	155	154	156	152	158	157	158	159	155	159	159	159	159	162	161
153	154	151	155	154	153	155	157	158	157	157	157	157	161	161	156	158	158	160
154	154	155	156	155	156	155	156	158	154	159	161	160	157	157	160	162	158	162
162	157	155	154	156	155	156	157	155	161	157	161	162	163	162	161	163	168	159
158	155	156	157	160	157	157	162	157	160	158	163	162	159	160	162	162	163	161
161	157	158	157	159	156	156	157	160	159	162	159	162	157	163	165	162	163	165
158	159	163	157	158	155	163	159	158	158	162	162	161	164	163	166	162	166	158
154	154	156	156	159	155	156	159	157	159	159	157	158	162	164	162	161	164	162
152	155	155	156	158	155	157	160	161	158	161	161	160	161	161	161	162	162	161
154	155	156	155	156	154	160	154	156	160	157	161	161	159	162	161	161	163	161
155	158	160	155	159	160	156	158	162	164	162	163	165	165	166	162	158	166	167
159	158	157	157	160	160	158	157	158	162	161	161	166	163	162	164	163	165	162
155	158	156	158	159	157	156	158	159	160	162	162	159	161	160	161	163	162	164
156	159	157	157	154	154	159	160	159	158	162	159	159	160	161	164	163	164	165
152	156	150	153	155	159	153	158	156	161	157	161	158	159	157	162	163	160	162
155	156	153	153	158	156	159	160	157	159	163	155	163	162	157	163	162	166	163
:																		
:																		

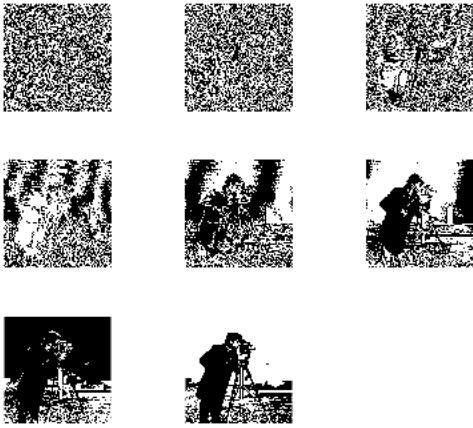
```
bitget(img, 1) % 產生右邊數來第 1 個 bit plane
```

```
ans = 256x256 uint8 matrix
```

0	1	0	1	0	0	1	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	1
0	0	1	0	1	1	0	0	0	0	1	0	1	0	0	0	1	1	1	1	0	0	0	1	1	1	0	0	1
0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1	1	1	0	0	0	1	1	1	1	1	0	1
0	0	1	0	1	1	0	0	0	0	1	0	1	0	0	1	1	1	1	0	0	0	1	1	1	0	0	1	0
0	1	1	1	1	1	0	1	1	1	1	0	0	0	1	1	0	0	1	1	1	0	1	1	1	0	0	1	0
1	1	1	1	0	1	0	0	0	0	0	1	1	0	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0
0	1	1	0	1	1	0	1	1	0	1	0	1	1	0	0	1	0	1	0	0	1	1	0	1	1	0	0	1
1	1	0	0	0	1	1	1	0	1	1	1	1	0	1	0	1	1	0	1	1	1	1	0	1	0	1	1	0
0	1	0	0	0	0	0	1	1	1	0	1	0	1	0	1	0	0	1	1	0	0	1	0	0	0	0	0	1
1	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	1	1	0	1	0	1	1	1	1	0	1
0	1	1	1	0	1	1	0	1	0	1	0	0	0	1	0	1	1	1	0	0	1	1	0	1	0	1	0	1
0	0	1	0	0	0	1	0	1	0	1	1	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	1
1	1	0	1	0	1	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
1	0	1	0	0	0	0	0	1	1	0	0	1	1	1	0	1	0	1	1	0	1	1	0	1	0	1	0	0
0	1	1	0	1	1	0	0	1	0	1	0	0	1	0	0	1	1	1	1	0	1	0	1	0	1	0	1	0
1	0	1	1	1	0	1	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	1	1	0	0	0	1	0	1	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	1	1	1	0	1
1	1	0	1	0	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	1	0

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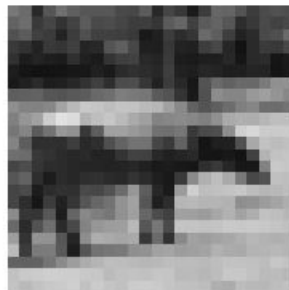
end



Spatial Resolution

一張圖片裡面的像素個數稱為空間解析度 (Spatial Resolution), 空間解析度越高, 圖片越清楚, 用 *imresize* 可以調整圖片大小。如果把圖片邊常都變 $1/2$, 就會每隔一行抽掉一行, 剩下一半的行數。然後放大 2 倍就會複製隔壁的行變回原來的數量, 因此這樣解析度就會變一半

```
img = imread("D:\Dropbox\wave\In class\4thup\image processing\Original_Images_1\buffalo.png");
for i = 1:4
    subplot(2, 2, i);
    imshow(imresize(imresize(img, 1/2^i), 2^i, "nearest"))
end
```



上面的圖分別就是原本解析度的 $1/4$, $1/16$, $1/64$, $1/128$ 倍