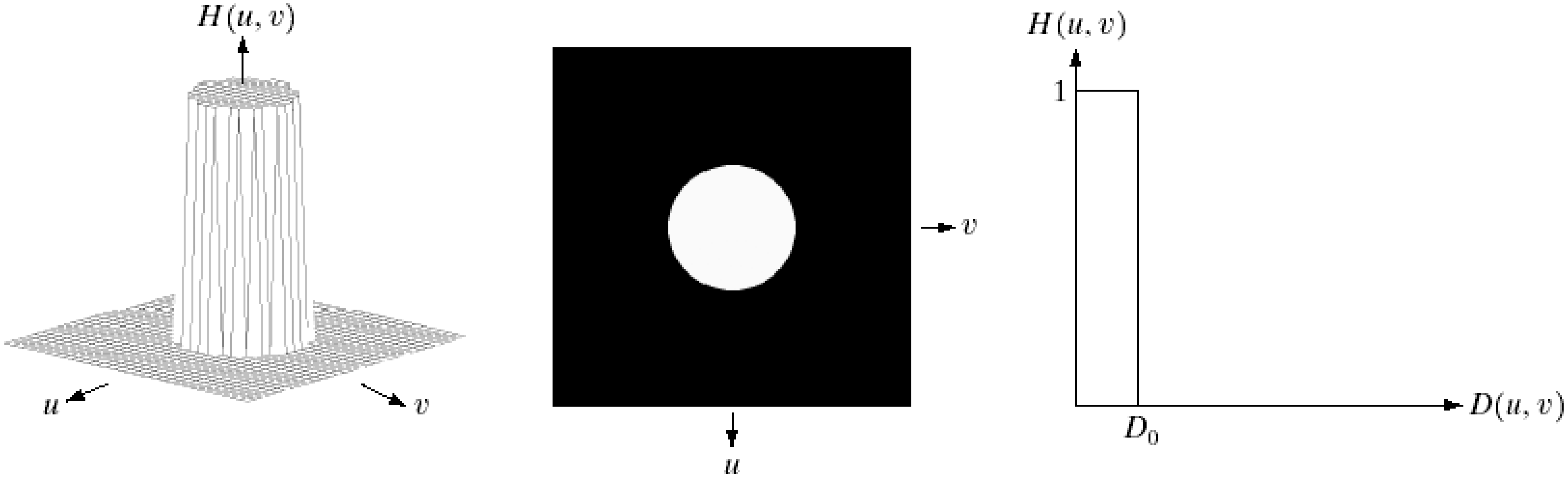
Ideal lowpass filters



a b c

FIGURE 4.10 (a) Perspective plot of an ideal lowpass filter transfer function. (b) Filter displayed as an image. (c) Filter radial cross section.

Butterworth Lowpass Filter

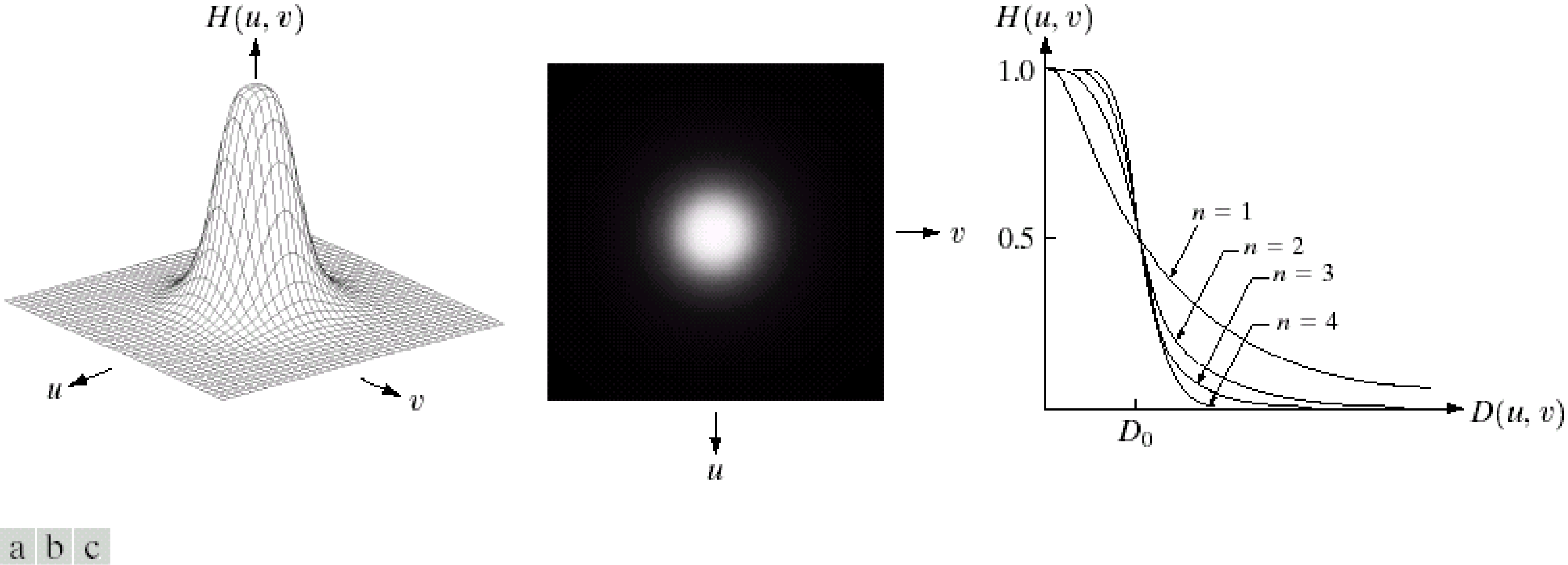


FIGURE 4.14 (a) Perspective plot of a Butterworth lowpass filter transfer function. (b) Filter displayed as an image. (c) Filter radial cross sections of orders 1 through 4.

a
b c
d e

FIGURE 3.44 A 3 × 3 region of an image (the z's are gray-level values) and masks used to compute the gradient at point labeled z_5. All masks coefficients sum to zero, as expected of a derivative operator.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

Roberts Cross-Gradient

−1	0
0	1

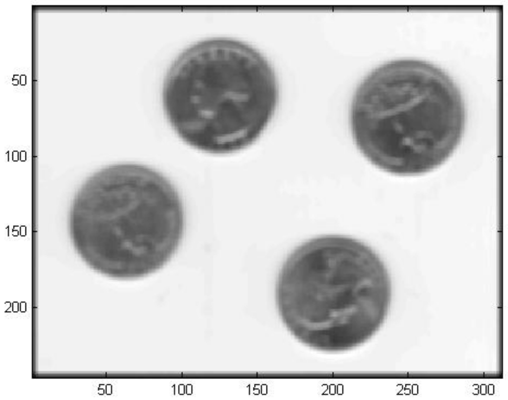
0	−1
1	0

Sobel Operators

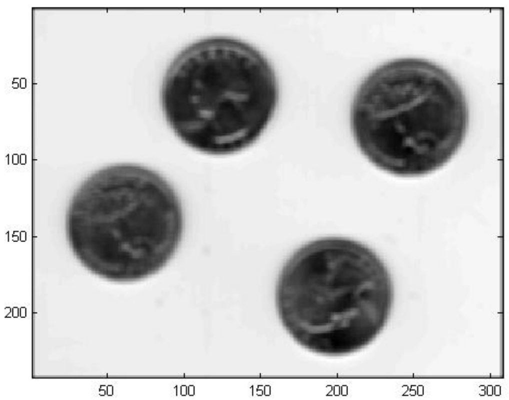
−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

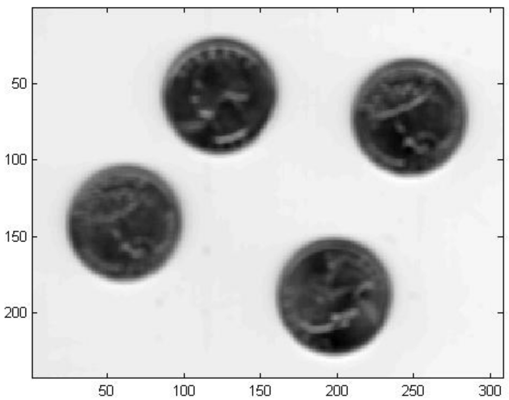
A (Original image)



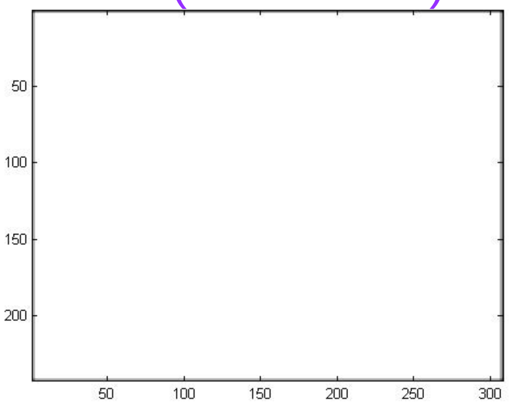
B (convolution)



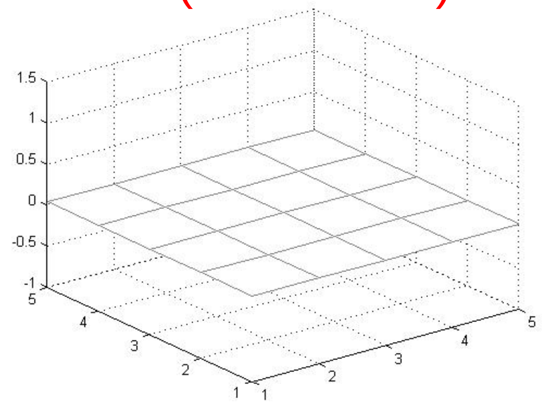
B (convolution)



B (convolution)

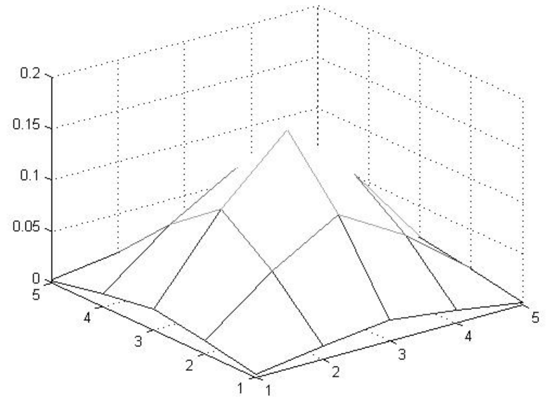


C1

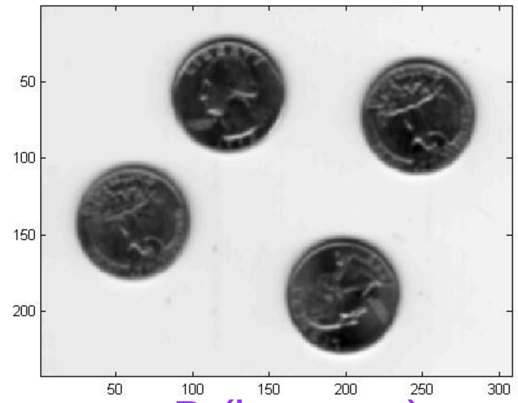


M

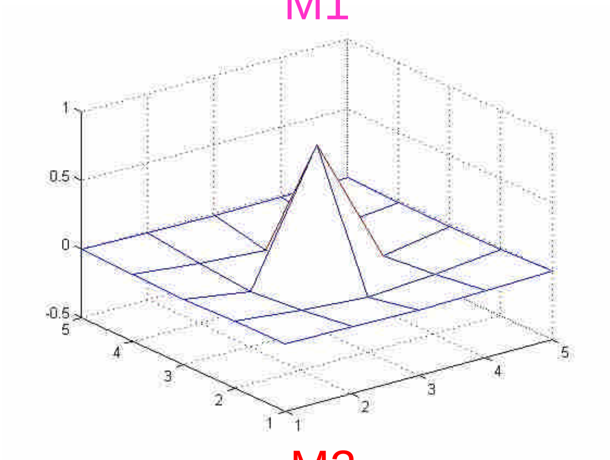
```
A=imread('eight.tif');
A=double(A);
imagesc(A)
colormap(gray)
M=ones(5)/25;
B=conv2(A,M);
figure
imagesc(B)
colormap(gray)
B=conv2(A,M,'same');
imagesc(B)
colormap(gray)
C=ones(size(B));
B=conv2(A,M,'same')./
conv2(C,M,'same');
imagesc(B)
colormap(gray)
C1=conv2(C,M,'same');
figure
colormap(gray)
imagesc(C1*255)
mesh(M)
```



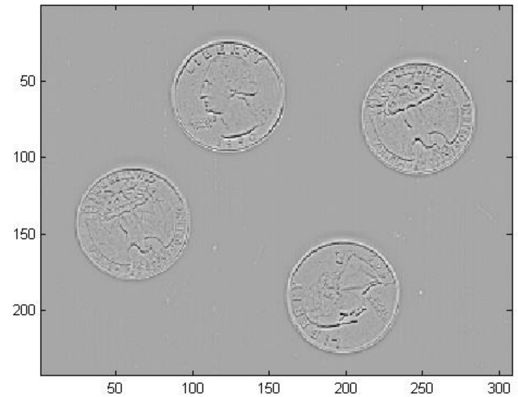
M1



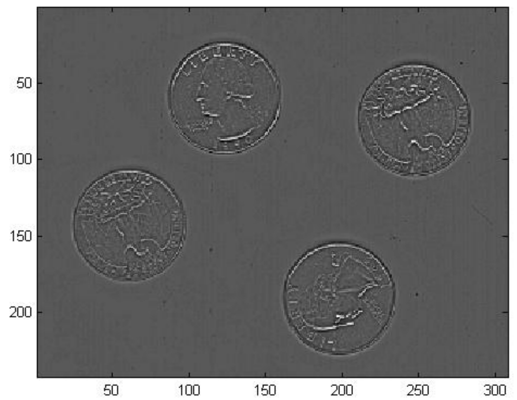
B (lowpass)



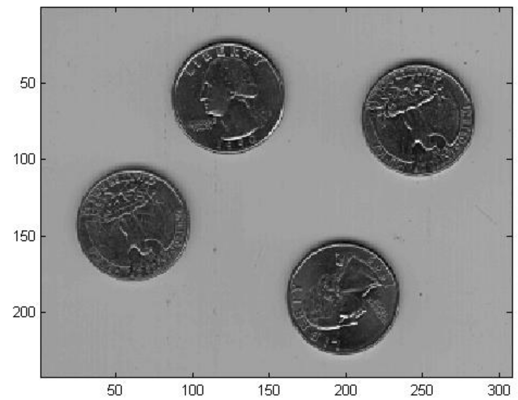
M2



B (highpass)



C (highpass=1-lowpass)



C+A (highboost)

```
f=[.05 .25 .4 .25 .05];
M1=f'*f;
mesh(M1)
B=conv2(A,M1,'same')./
conv2(C,M1,'same');
figure
imagesc(B)
colormap(gray)
D=zeros(5);
D(3,3)=1;
M2=D-M1;
mesh(M2)
B=conv2(A,M2,'same')./
conv2(C,M2,'same');
imagesc(B)
B=conv2(A,M1,'same')./
conv2(C,M1,'same');
C=A-B;
imagesc(C)
imagesc(C+A)
```

Butterworth Lowpass Filter

- This filter does not have a sharp discontinuity establishing a clear cutoff between passed and filtered frequencies.

$$H(u,v) = \frac{1}{1 + [D(u,v) / D_0]^{2n}}$$

where D_0 is the cutoff frequency , and D(u,v) is

$$D(u,v) = [(u - M/2)^2 + (v - N/2)^2]^{1/2}$$

- This is more appropriate for image smoothing than the ideal LPF, since this does not introduce ringing.

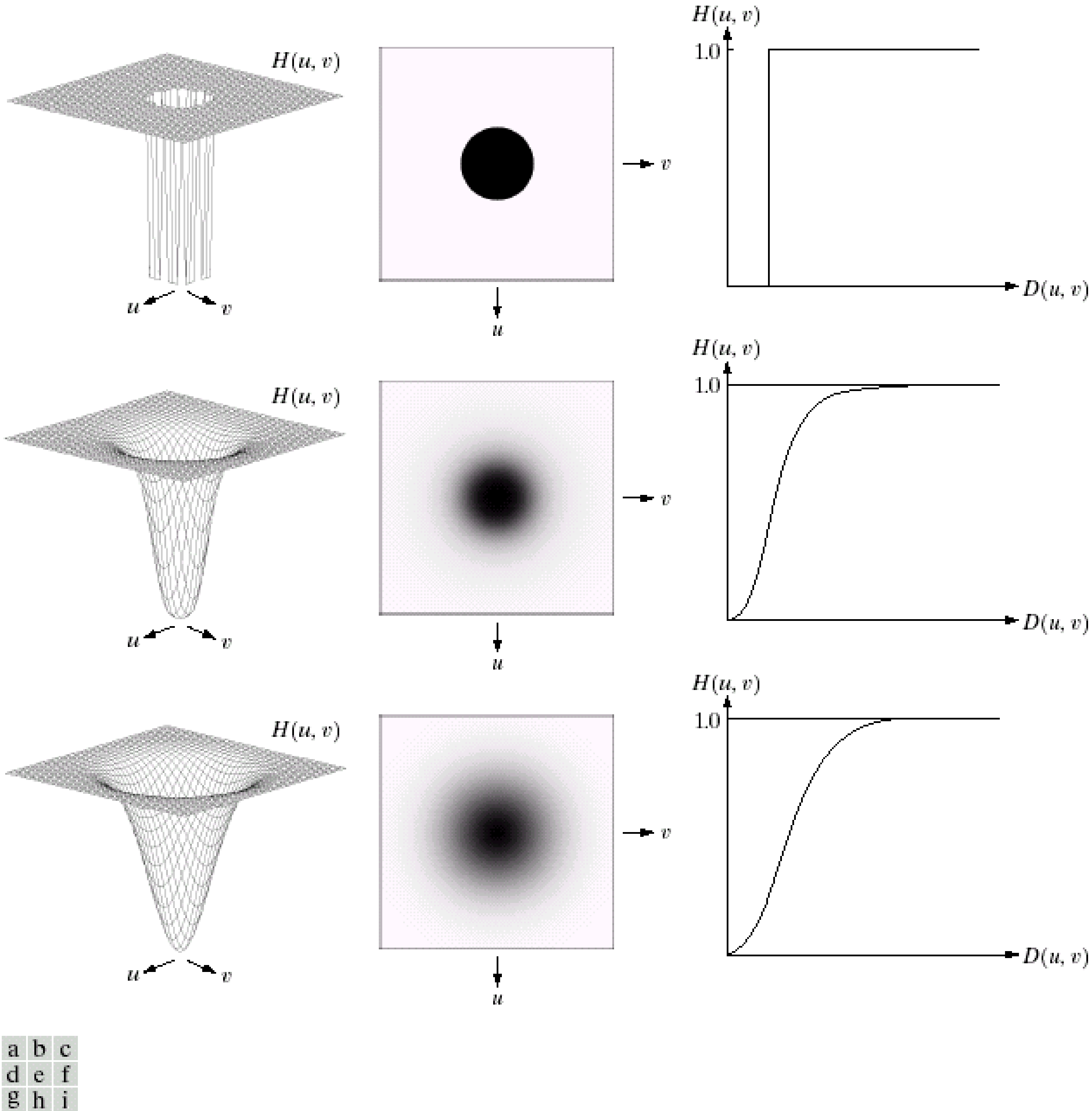


FIGURE 4.22 Top row: Perspective plot, image representation, and cross section of a typical ideal highpass filter. Middle and bottom rows: The same sequence for typical Butterworth and Gaussian highpass filters.

Gaussian Lowpass Filter

- Gaussian lowpass filter is defined by

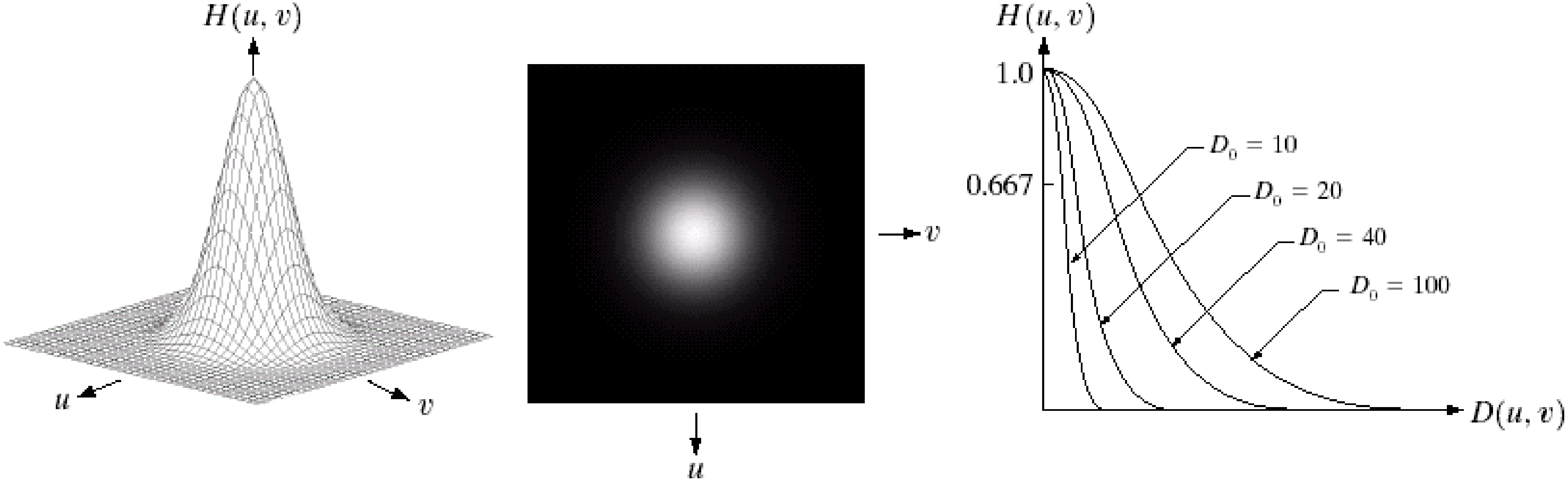
$$H(u,v) = e^{-D^2(u,v)/2\sigma^2}$$

D(u,v) is the distance from the origin of the Fourier transform.
by letting σ =D_0, we have

$$H(u,v) = e^{-D^2(u,v)/2D_0^2}$$

where D_0 is the cutoff frequency.

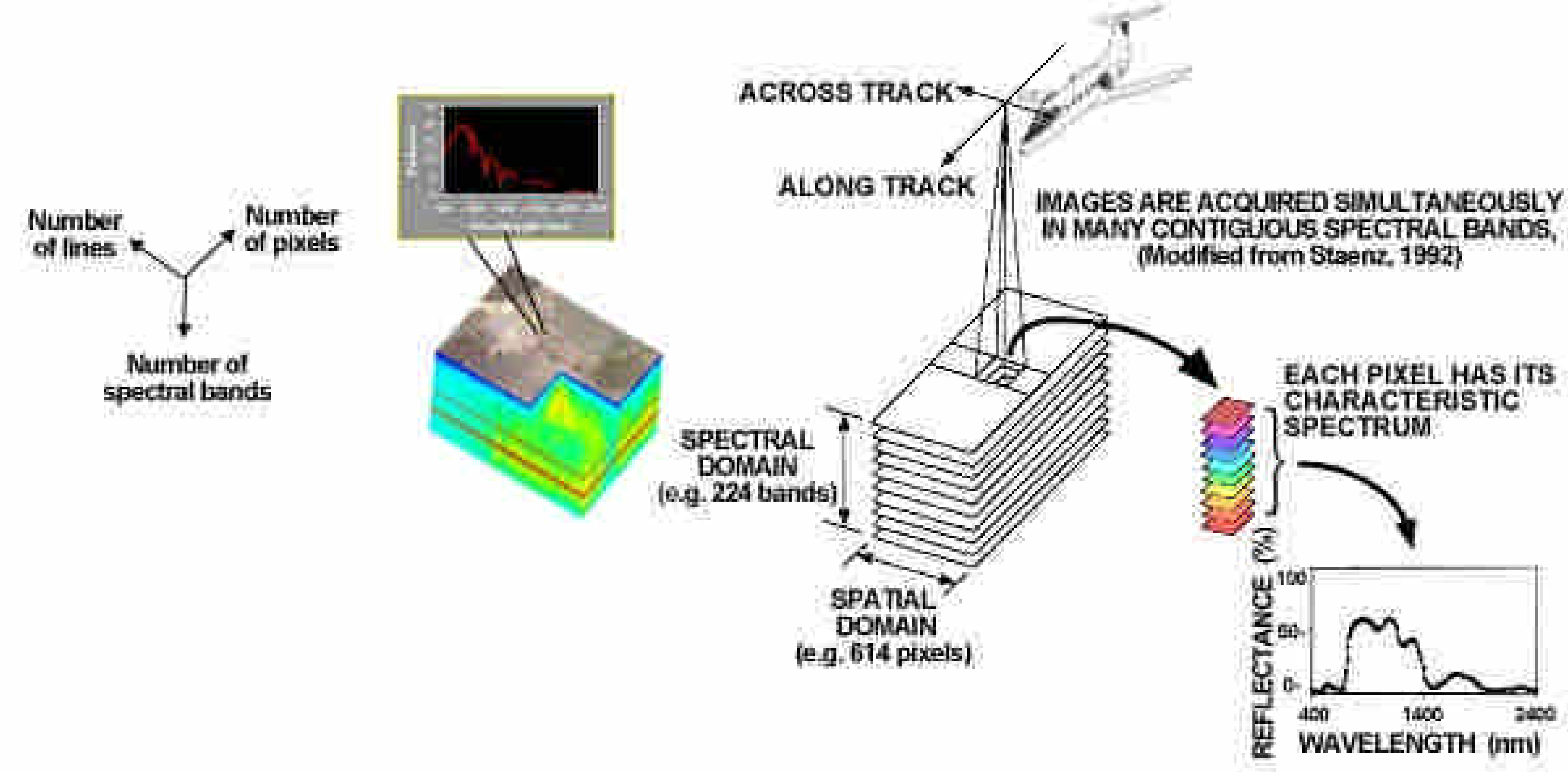
Gaussian Lowpass Filter



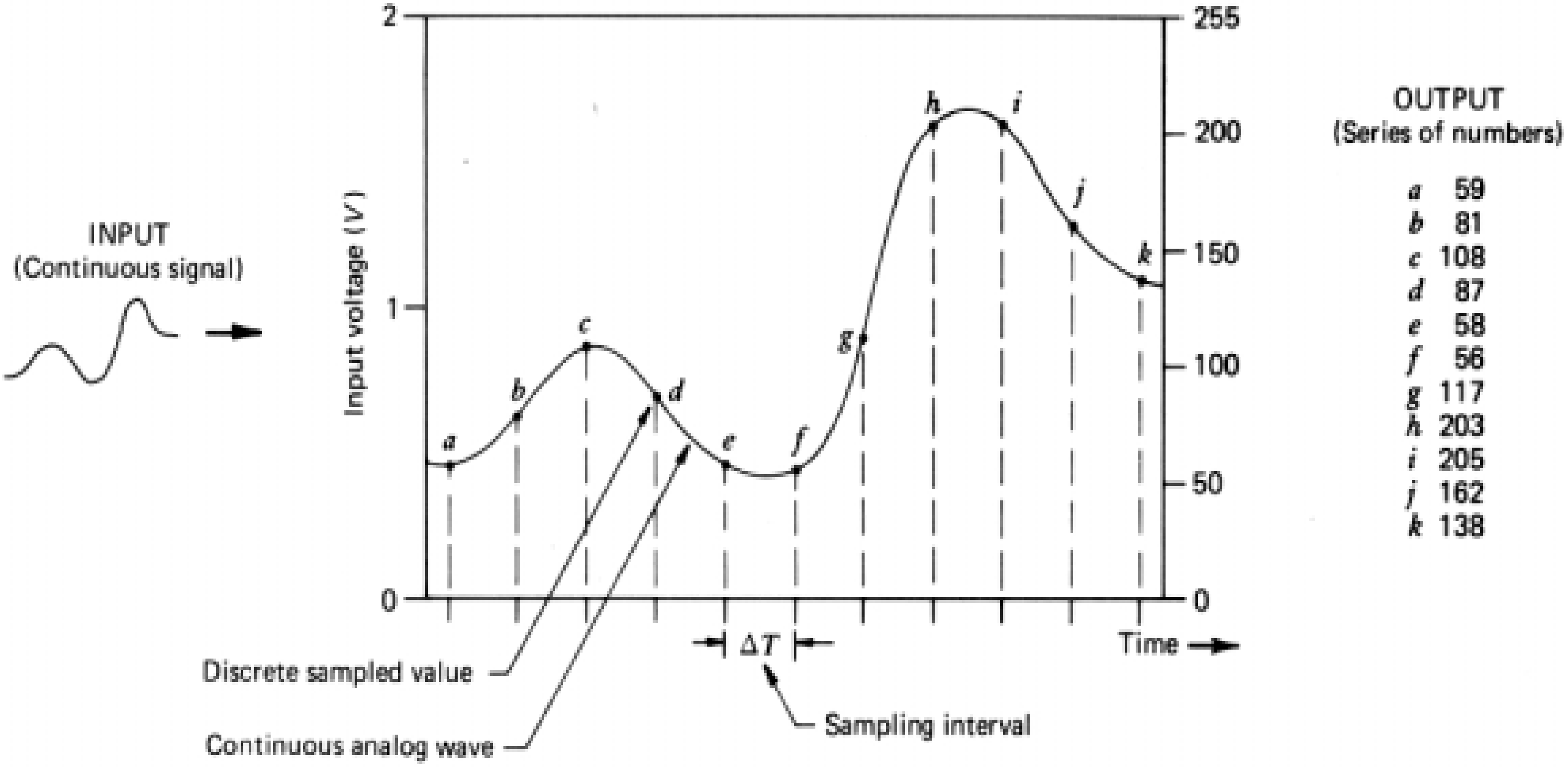
a b c

FIGURE 4.17 (a) Perspective plot of a GLPF transfer function. (b) Filter displayed as an image. (c) Filter radial cross sections for various values of D_0.

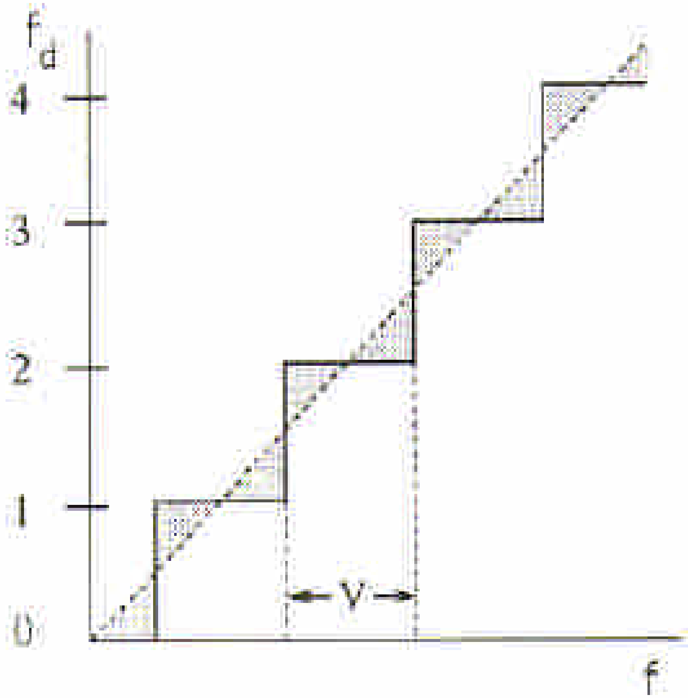
Digital Remote Sensing Image



Radiometric Resolution



Quantization



f : analogue intensity

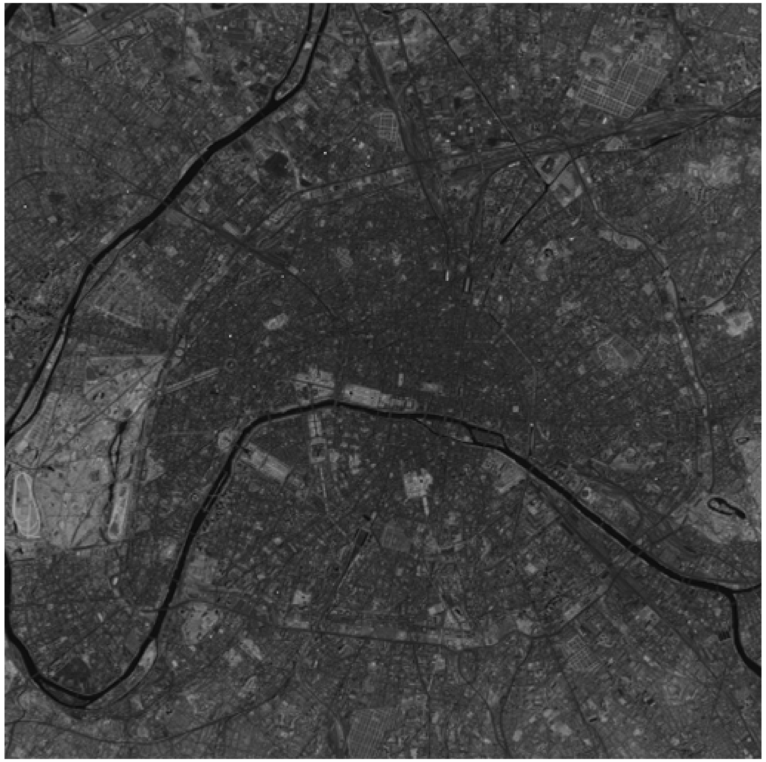
f_d : quantized intensity

V : unit intensity

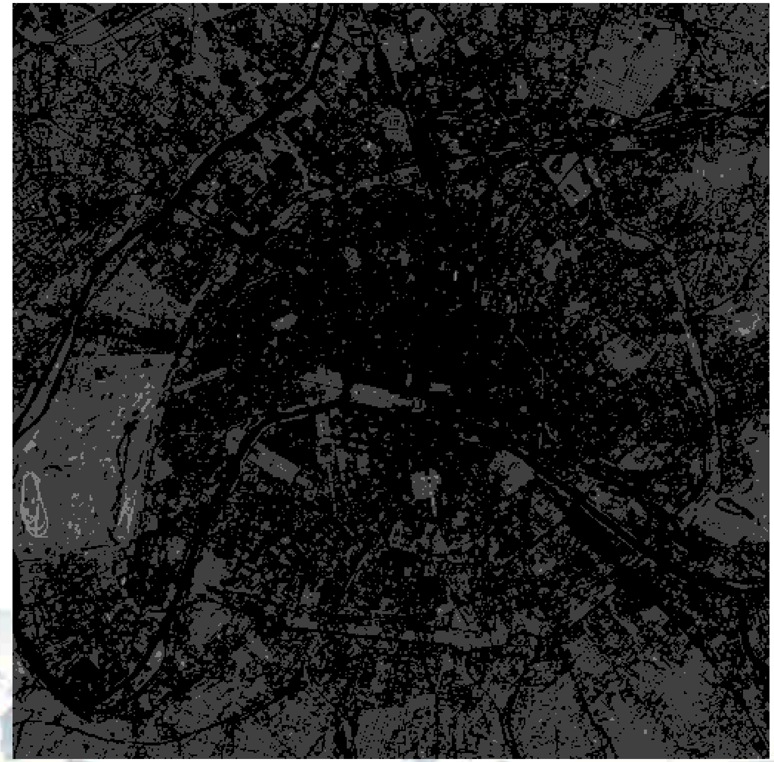
n : integer

$(n-0.5)V \leq f < (n+0.5)V \rightarrow f_d = n$

quatization error $= f - f_d$ (shaded part)

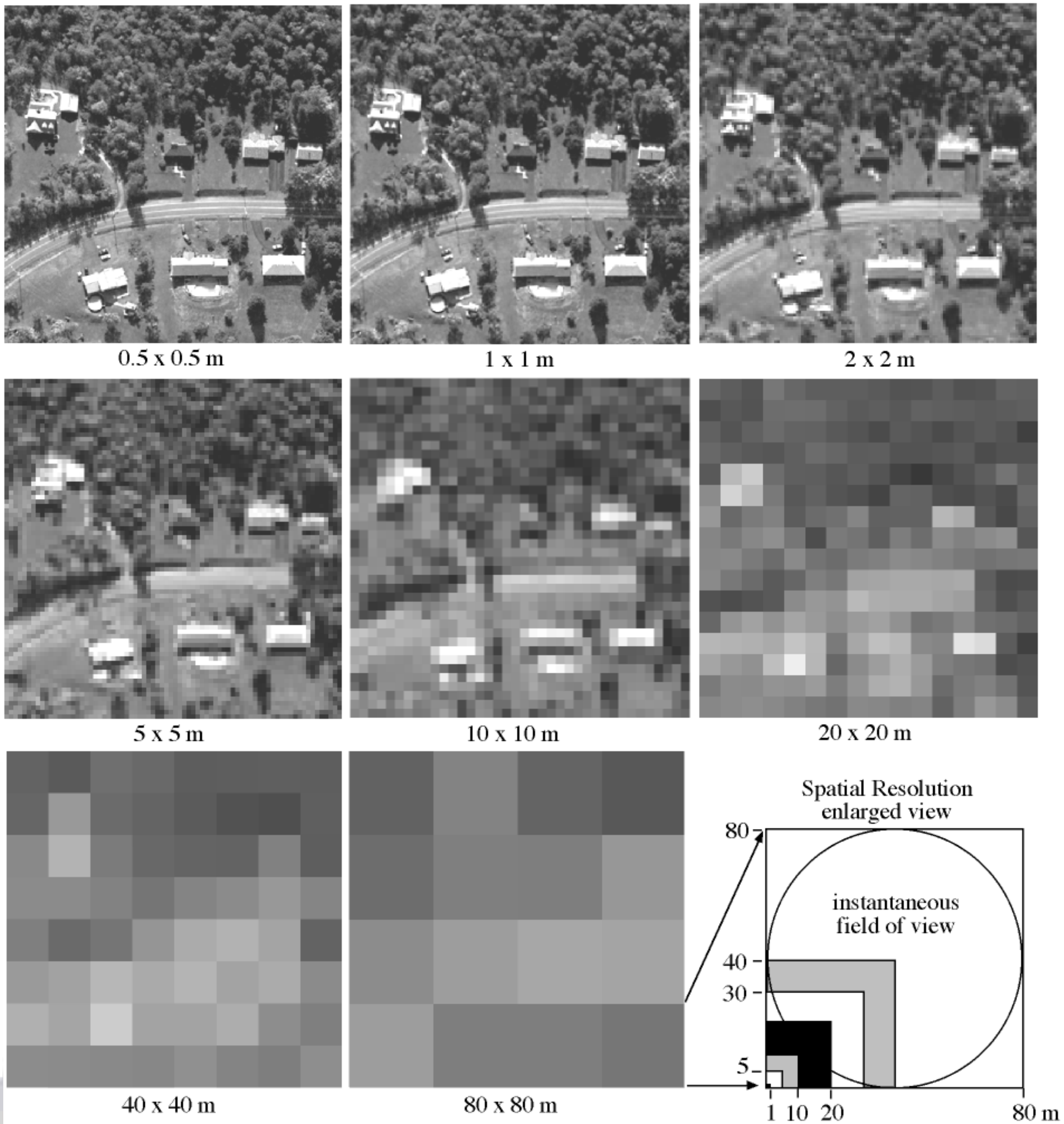


8 bits

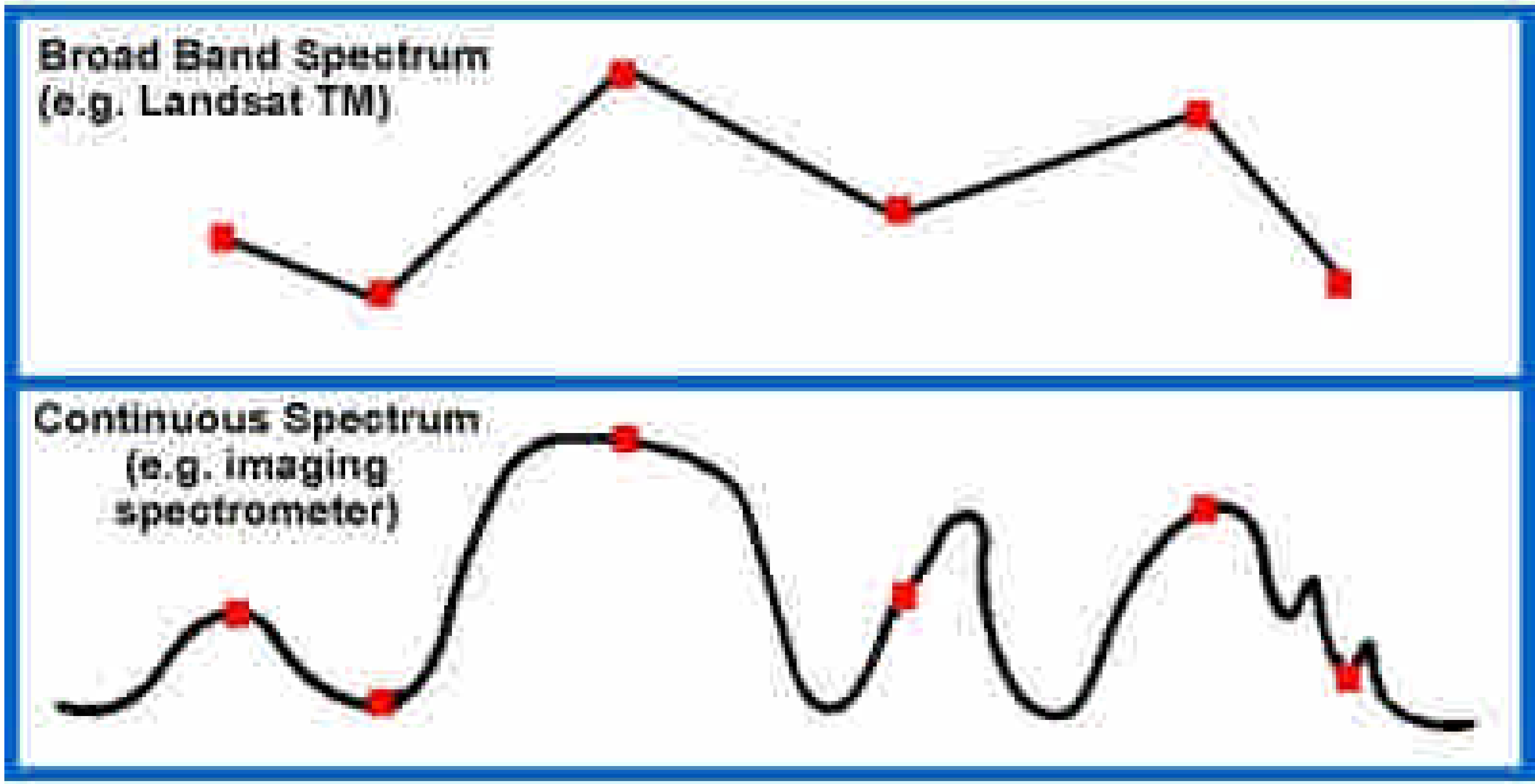


2 bits

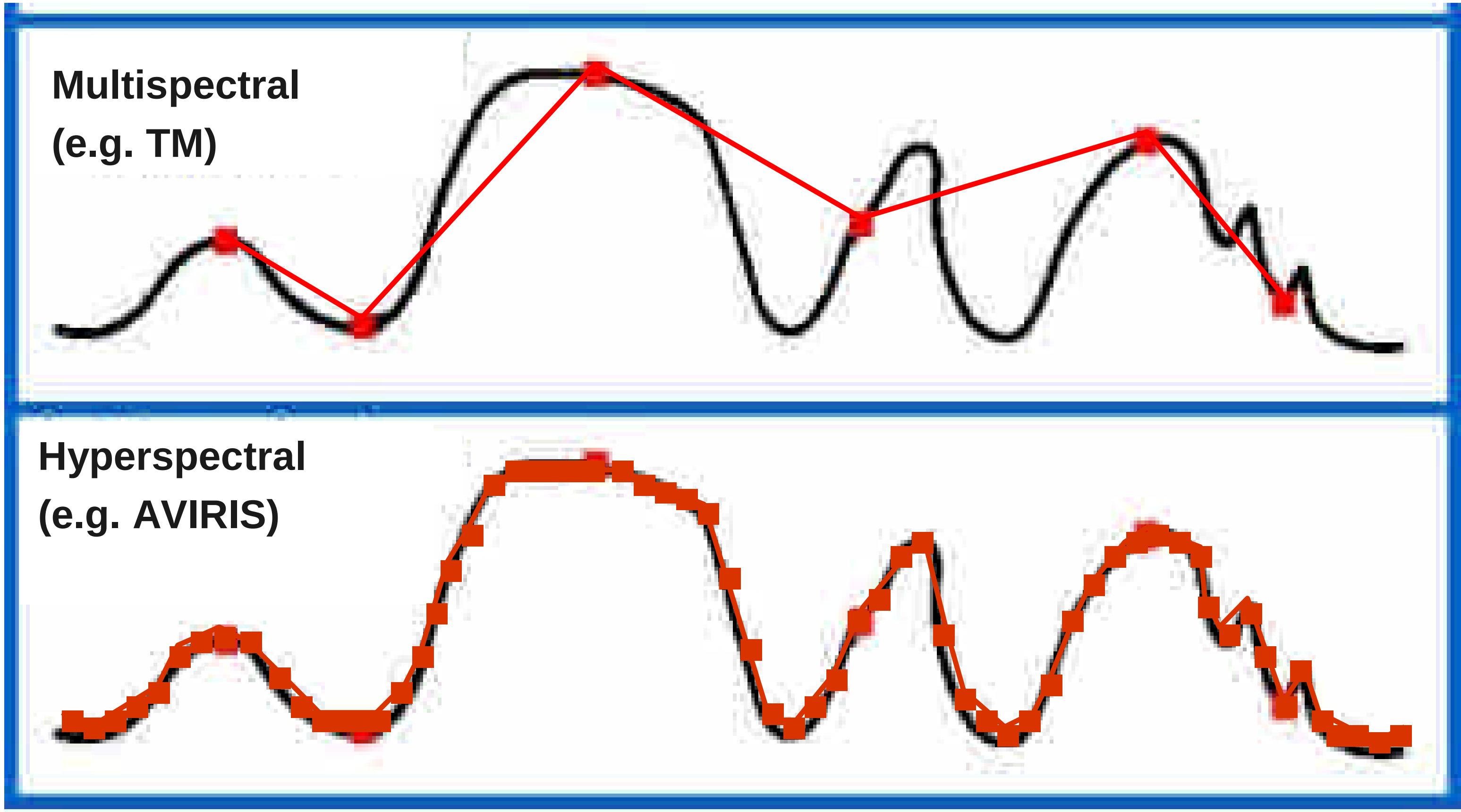
Spatial Resolution

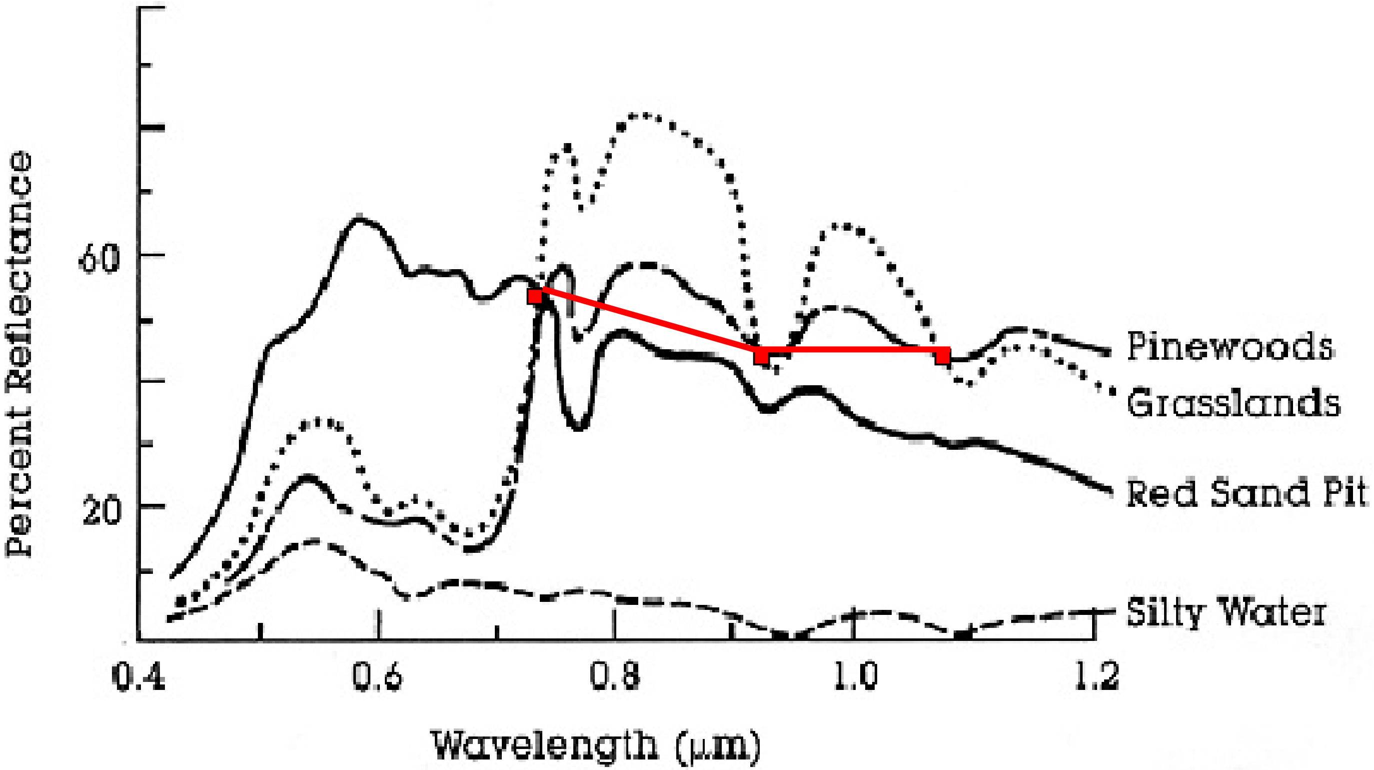


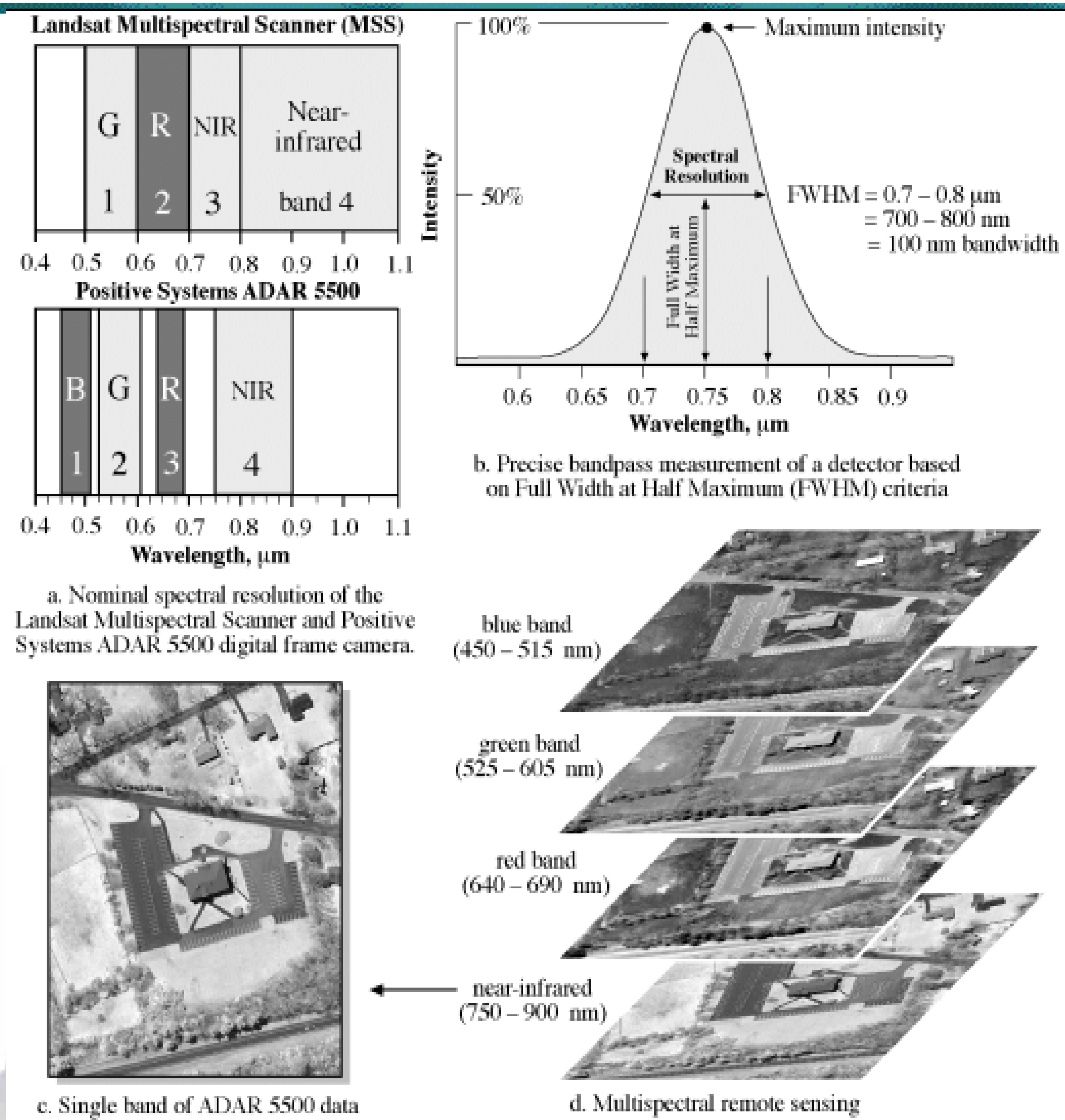
Spectral Resolution



Multispectral vs Hyperspectral




Percent Reflectance
60
20
0.4
0.6
0.8
1.0
1.2
Wavelength (μm)
Pinewoods
Grasslands
Red Sand Pit
Silty Water



a. Nominal spectral resolution of the Landsat Multispectral Scanner and Positive Systems ADAR 5500 digital frame camera.

b. Precise bandpass measurement of a detector based on Full Width at Half Maximum (FWHM) criteria

c. Single band of ADAR 5500 data

d. Multispectral remote sensing

Temporal Resolution

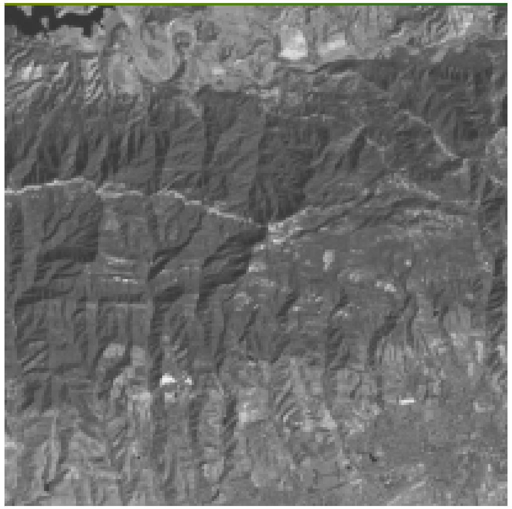
System	Resolution (day)
Landsat 1, 2, 3	18
Landsat 4, 5	16
AVHRR	1
SPOT	26
MODIS	2

Data Compression

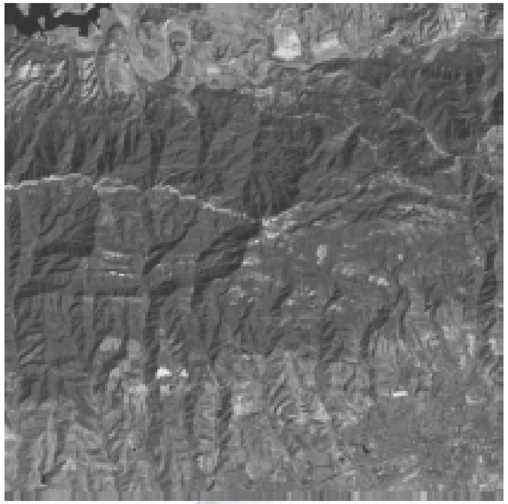
- SPOT5
  - XI: XS1, XS2, XS3: 10m
  - SWIR: 20m
  - PAN: 5m
  - 60km x 60km:
    - XI: $(60000(m)/10(m))^2$x3(band)=108 MB
    - SWIR: $(60000(m)/20(m))^2$=9 MB
    - PAN: $(60000(m)/5(m))^2$=144 MB
    - Total: 261 MB

COMPRESSION TYPE
Lossless
Run Length Coding
Huffman Coding
Lossy
Joint Photographic Experts Commission (JPEG) - DCT
Vector Quantization (VQ)

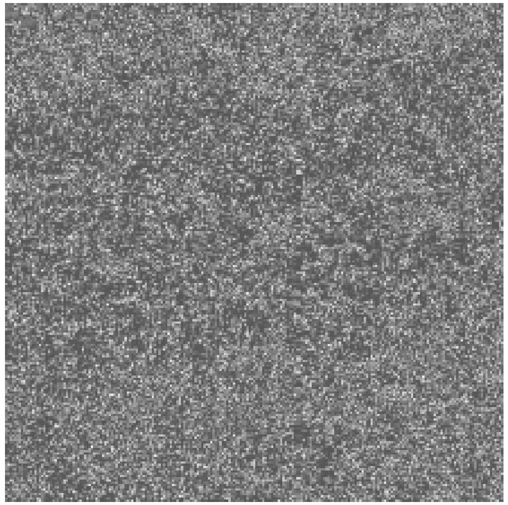
Vector Quantization



Original

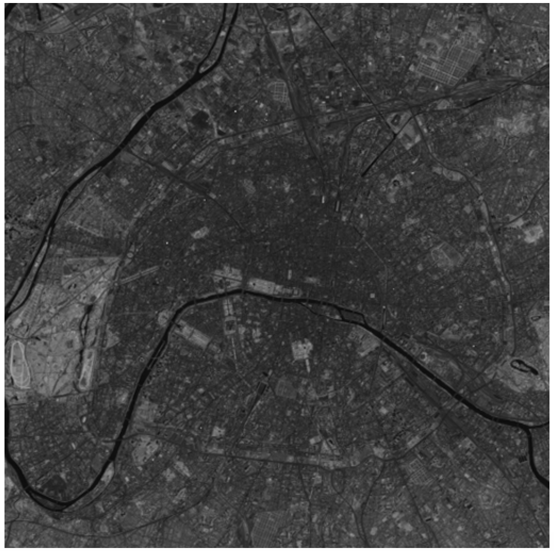


10:1 ratio

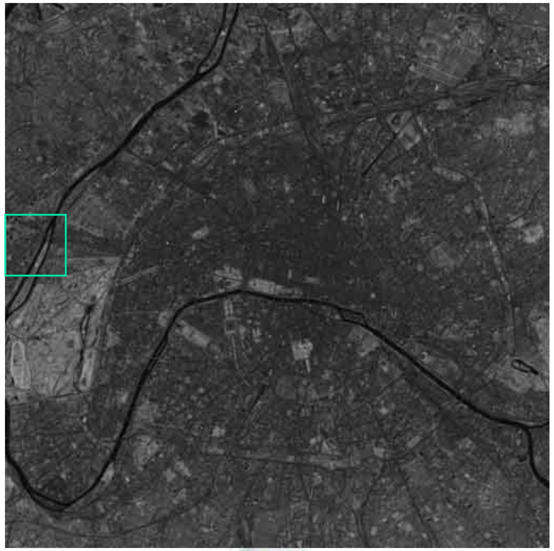


Error

JPEG



Original



8:1 ratio

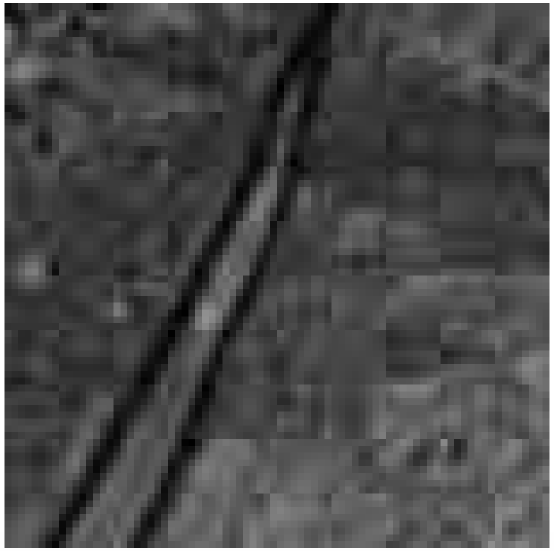
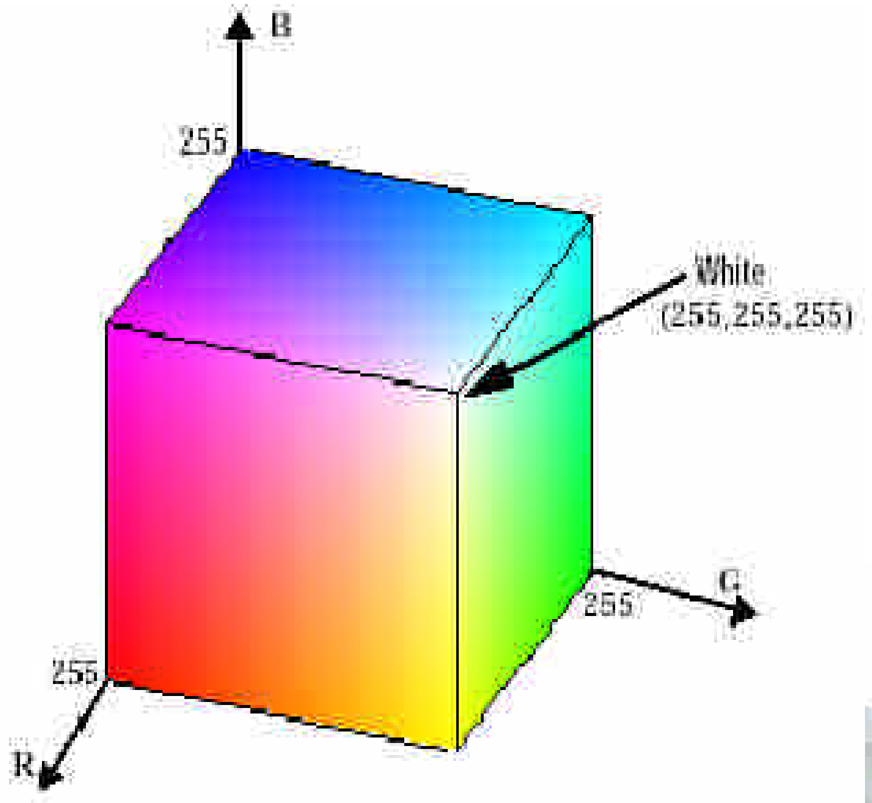


Image Display

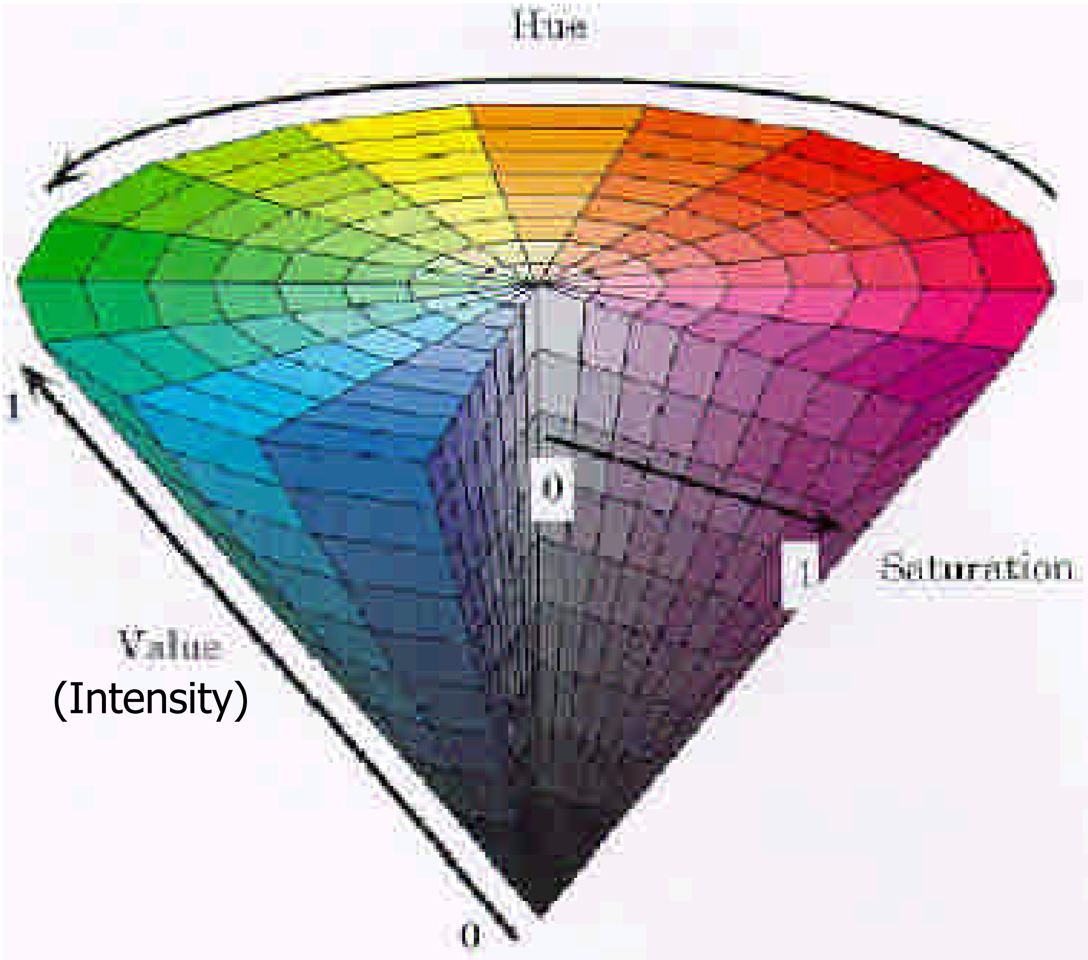
- False color
- Pseudo color
- Color system

Color



Color coordinate

Hue, Saturation, Value (HSV)
(色調, 飽和度, 亮度)



亮度變化

飽和度變化


Change in Saturation
original
40% saturation
160% saturation

色調變化

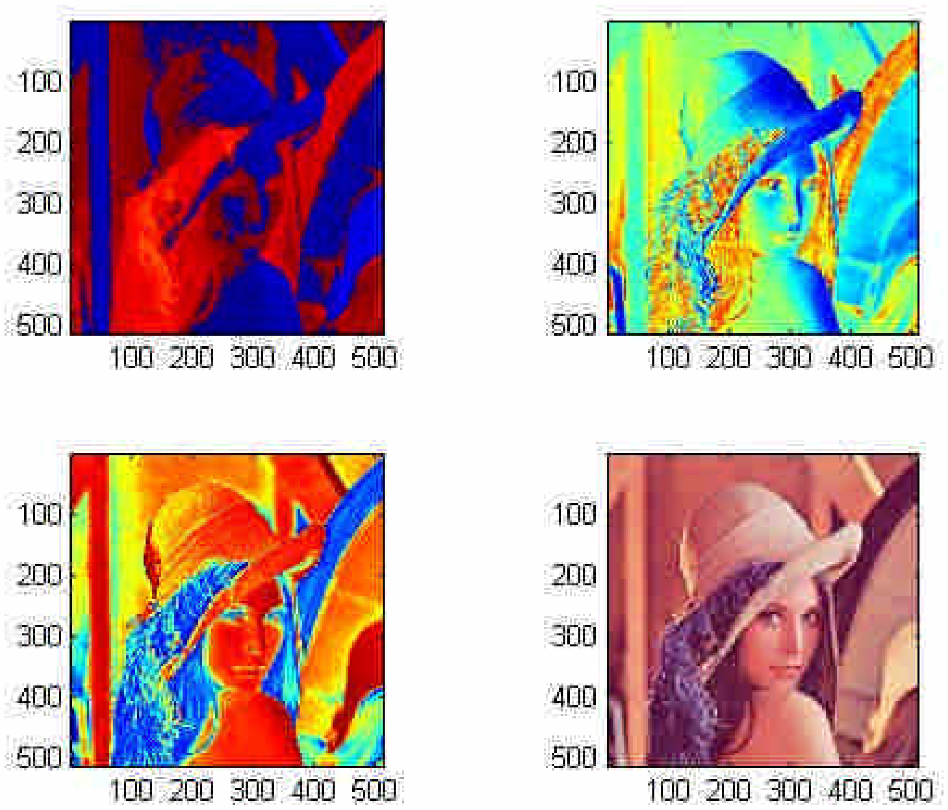
其他色彩系統

- YIQ:
  - 電視系統
- YUV:
  - PAL 和數位影片
- CMY:
  - 印表機系統

色彩系統轉換

- **RGB to CMY**
  - C = W – R
  - M = W – G
  - Y = W – B
- **RGB to YIQ**
  - Y= 0.299R + 0.587G + 0.114B
  - I = 0.596R - 0.274G - 0.322B
  - Q = 0.211R - 0.523G + 0.312B
- **RGB to HSI**
  - H = (90 – arctan(F/1.71) + C) / 360, with F = (2R – G – B)/(G – B) and C = 0 if G > B, or C = 180, if G < B
  - S = 1 – min (R, G, B) / V,
  - I = (R + G + B) / 3.
- **RGB to YUV**
  - Y = 0.299R + 0.587G + 0.114B, Intensity, Luminance
  - U = 0.493 (B – Y),
  - V = 0.877 (R – Y), Color Differences, Chrominance

lena




```
A=imread('lena.jpg');
image(A);
B=rgb2hsv(A);
figure
for i=1:3,
subplot(2,2,i)
imagesc(B(:,:,i))
end
subplot(2,2,4)
imagesc(A);
```

Intensity

Original image

C

```
A=imread('lena.jpg');
image(A);
B=rgb2hsv(A);
B1=B;
B1(:,:,3)=B(:,:,3).^(1/2);
C=hsv2rgb(B1);
figure
image(C)
B1(:,:,3)=B(:,:,3).^(2);
C=hsv2rgb(B1);
figure
image(C)
```

C

Saturation

Original image

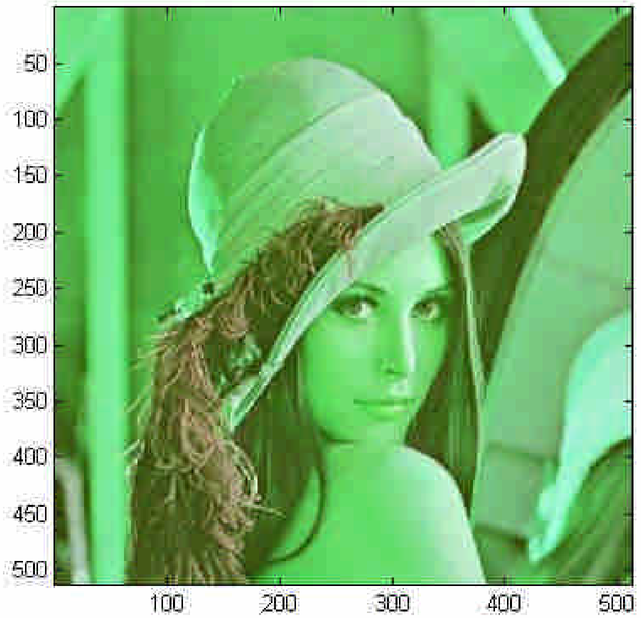
C

```
A=imread('lena.jpg');
image(A);
B=rgb2hsv(A);
B1=B;
B1(:,:,2)=B(:,:,2).^(1/2);
C=hsv2rgb(B1);
figure
image(C)
B1(:,:,2)=B(:,:,2).^(2);
C=hsv2rgb(B1);
figure
image(C)
```

C

Hue

Original image

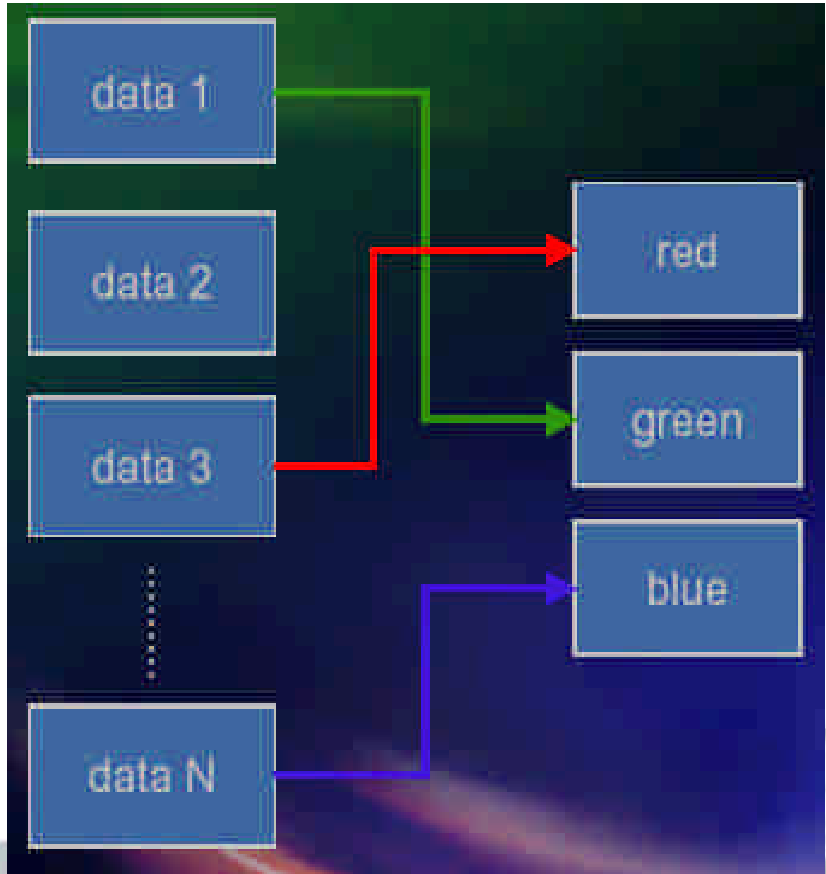


C

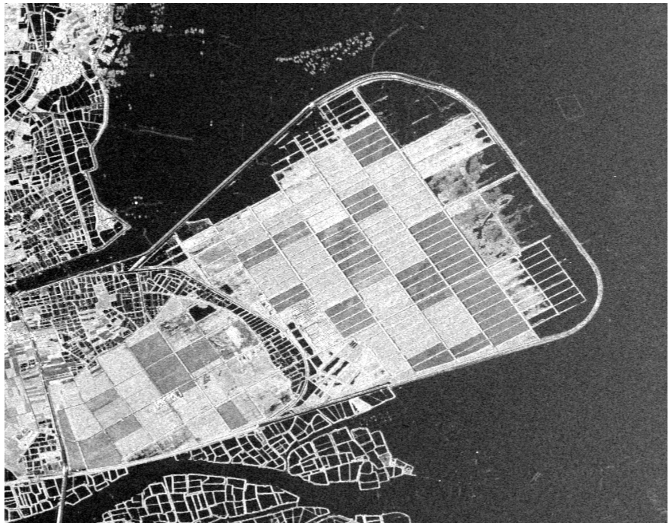
C

```
A=imread('lena.jpg');
image(A);
B=rgb2hsv(A);
B1=B;
B1(:,:,1)=mod(B(:,:,1)+(1/3),1);
C=hsv2rgb(B1);
image(C)
B1(:,:,1)=mod(B(:,:,1)-(1/3),1);
C=hsv2rgb(B1);
image(C)
```

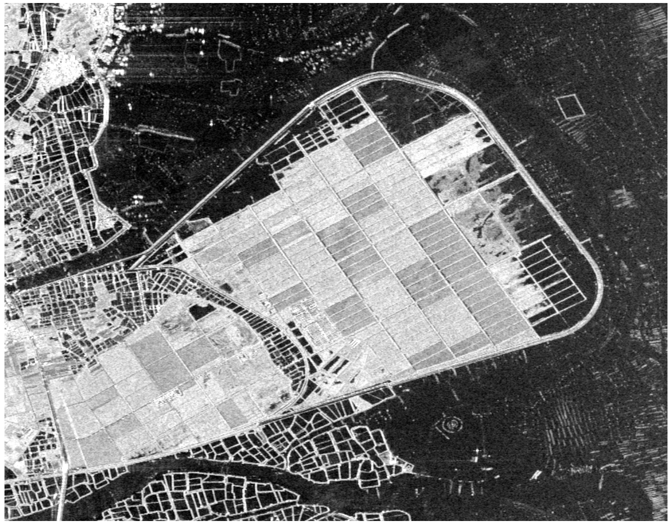
假色 (false color)



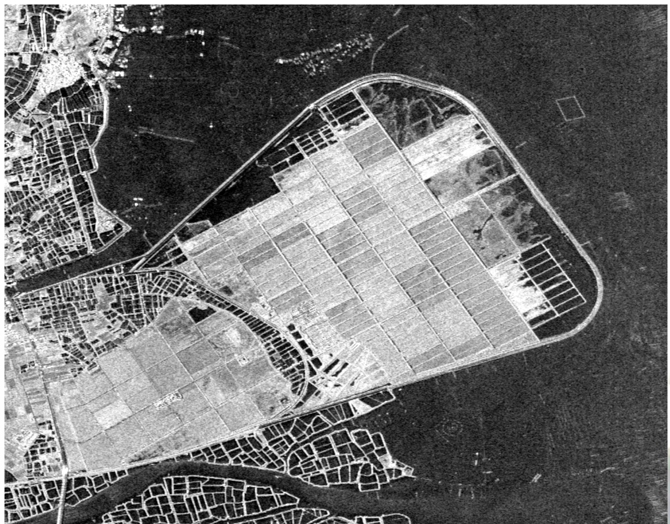
SAR Image



(a) C-band |HV|



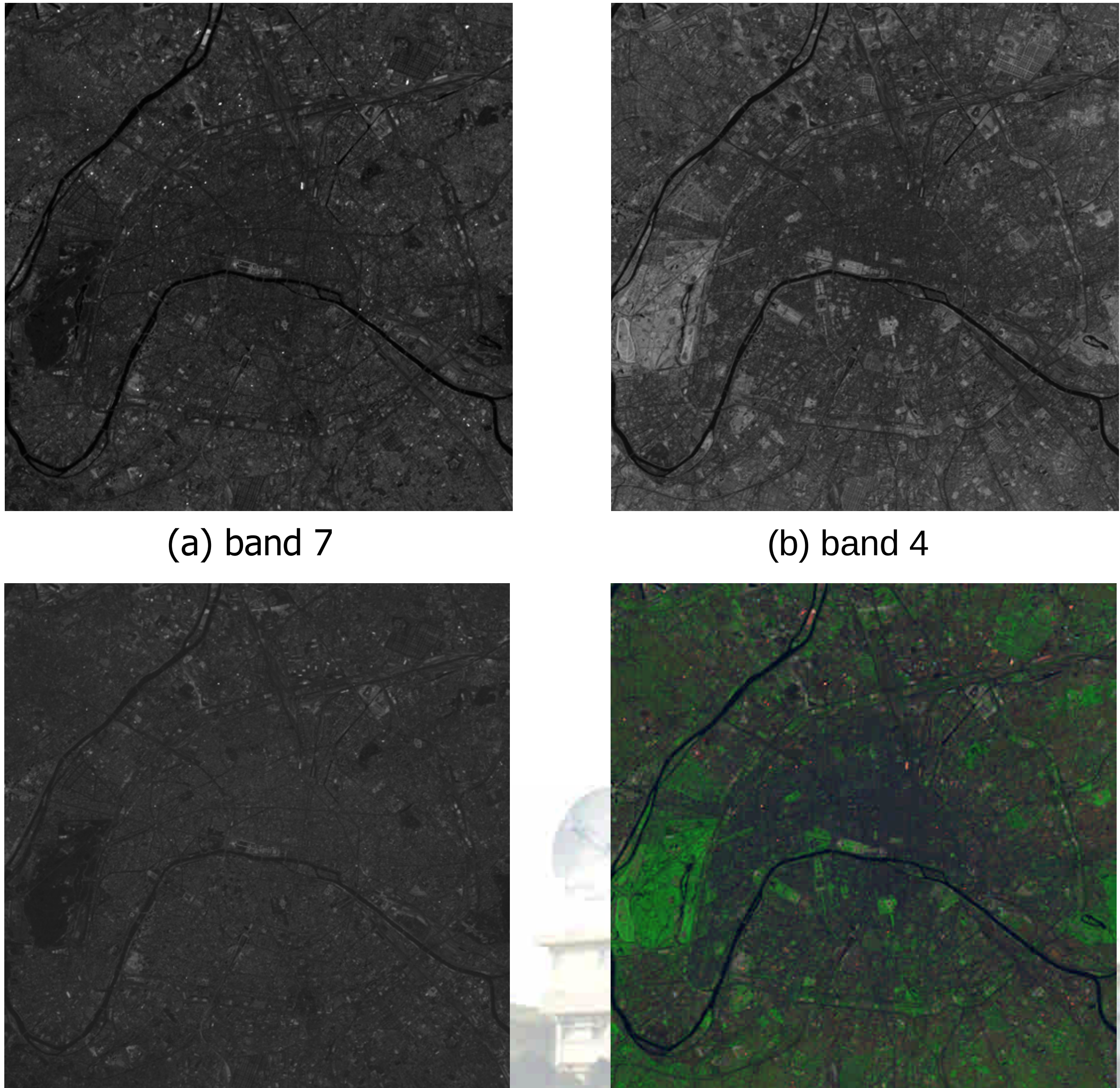
(b) C-band |HH|



(c) C-band |VV|

(d) 假色影像 (R: |HV| G: |HH| B: |VV|)

Landsat Image



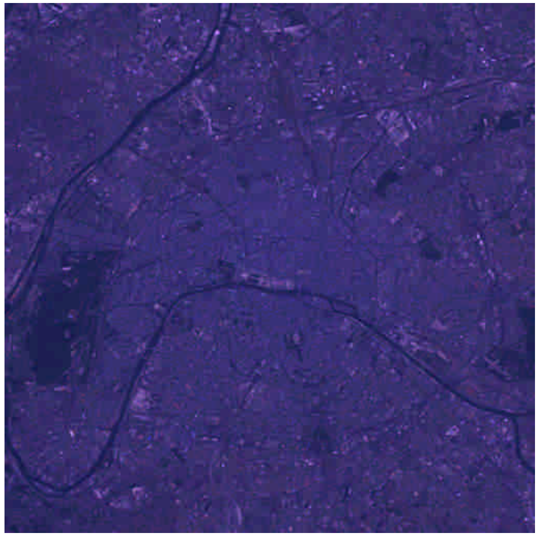
(a) band 7

(b) band 4

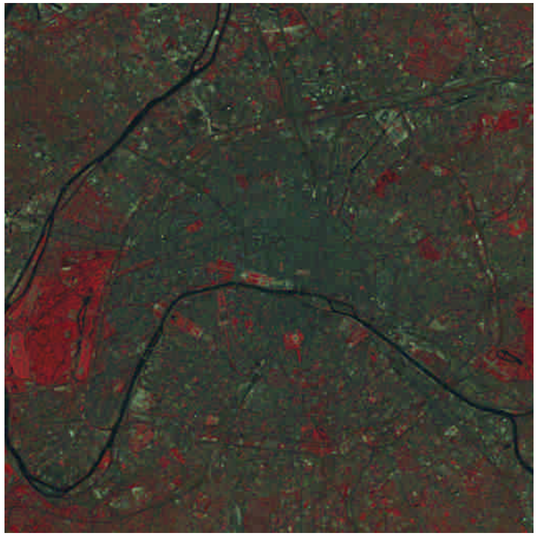
(c) band 2

(d) 假色影像 (R: 7 G: 4 B: 2)

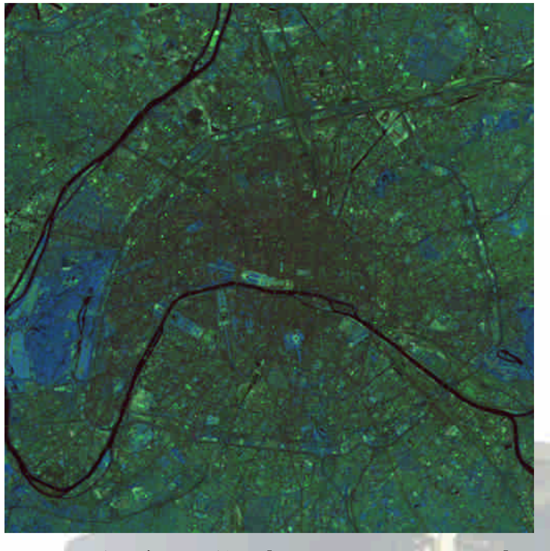
Landsat (false color)



(c)假色影像 (R: 3 G: 2 B: 1)



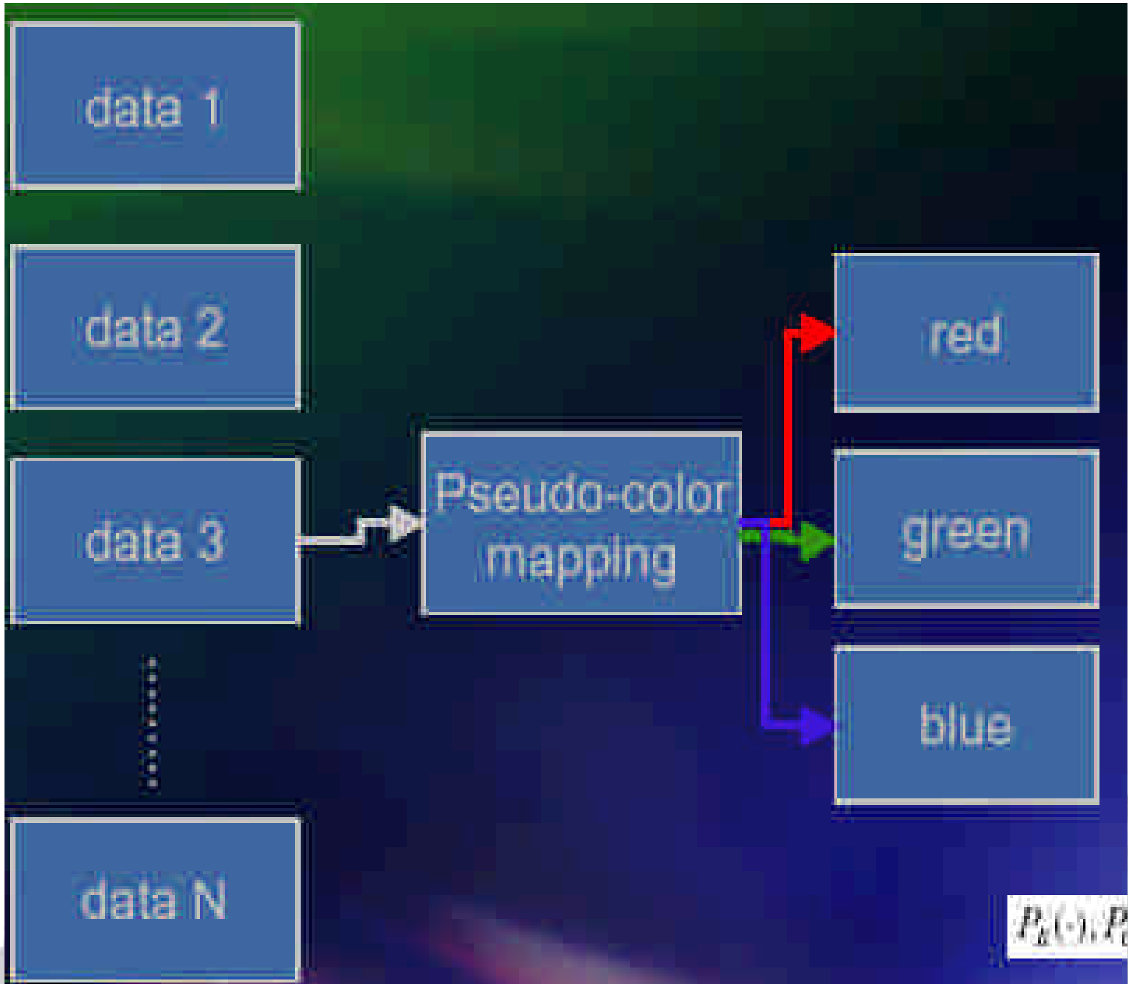
(d) 假色影像 (R: 4 G: 3 B: 2)



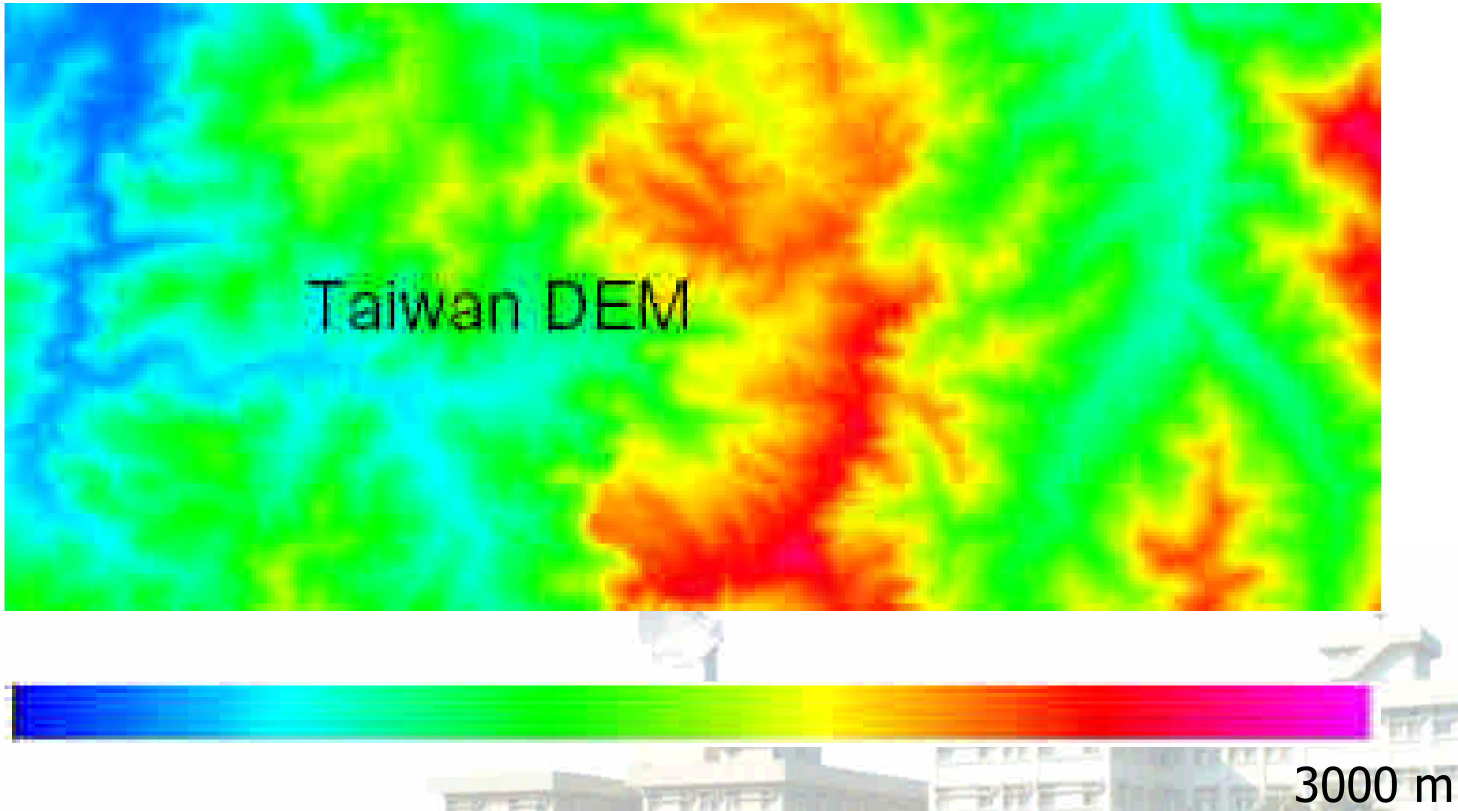
(c)假色影像 (R: 2 G: 5 B: 4)

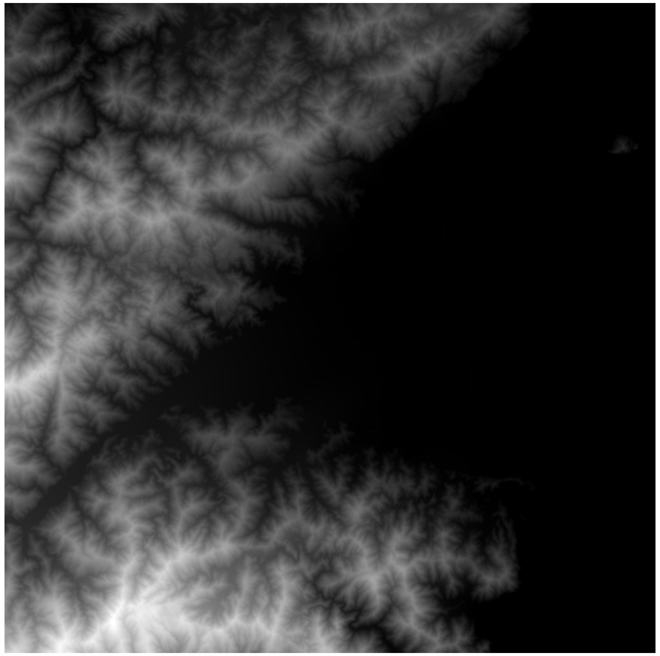
(d) 假色影像 (R: 7 G: 4 B: 1)

虛擬色 (Pseudo color)

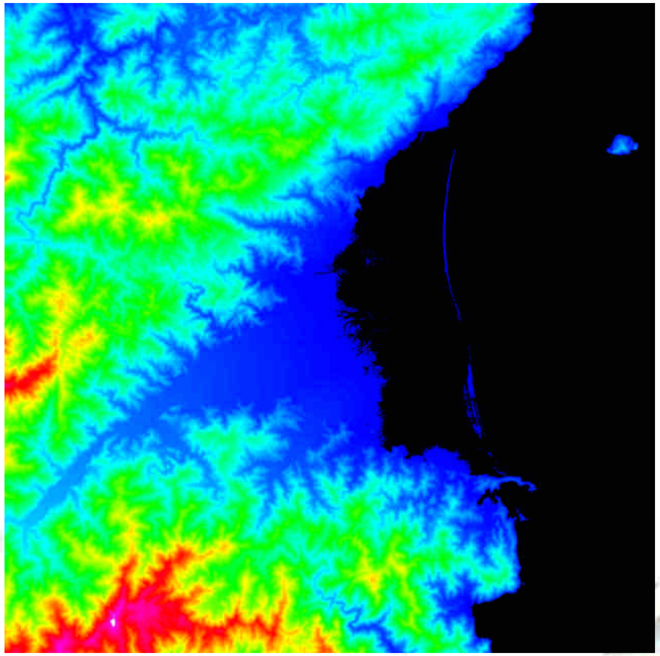


Digital Elevation Model





(a) Gray level



(b) Pseudo color

Color Space Transform

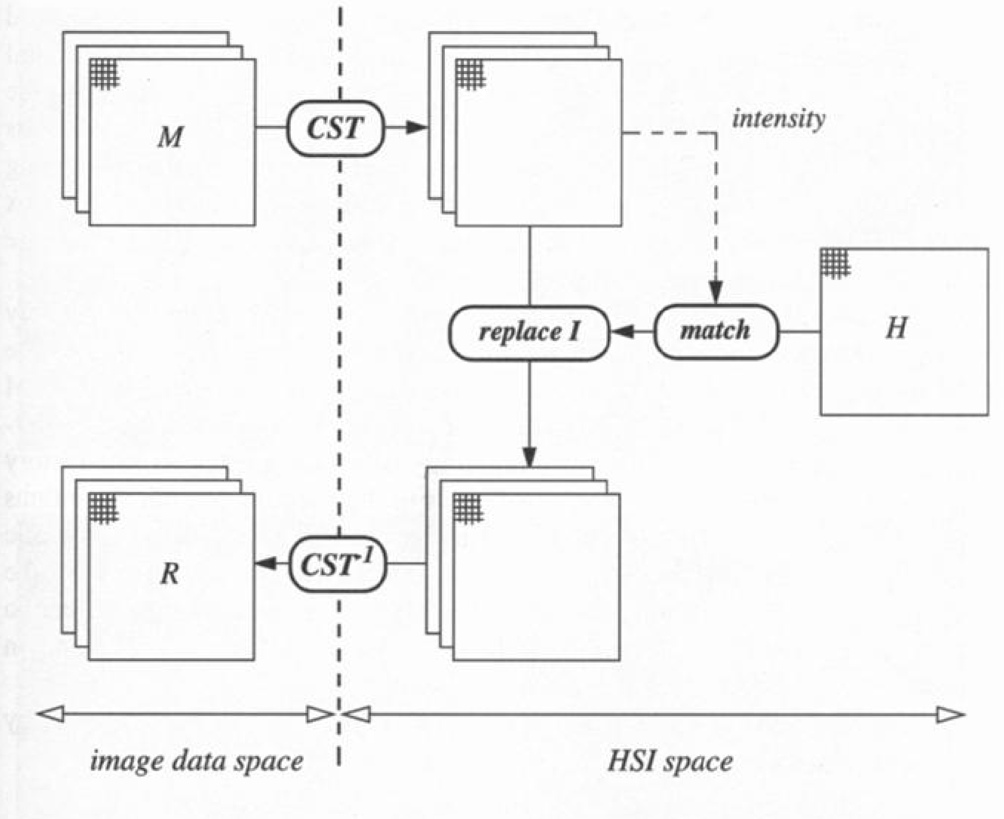
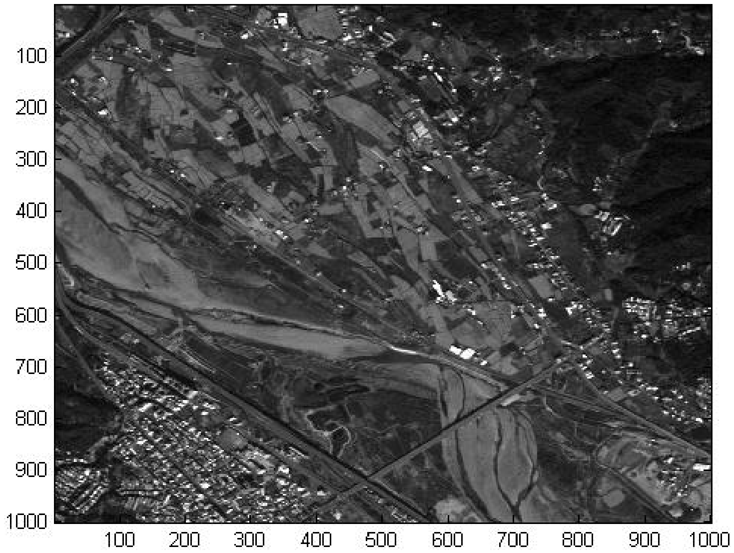
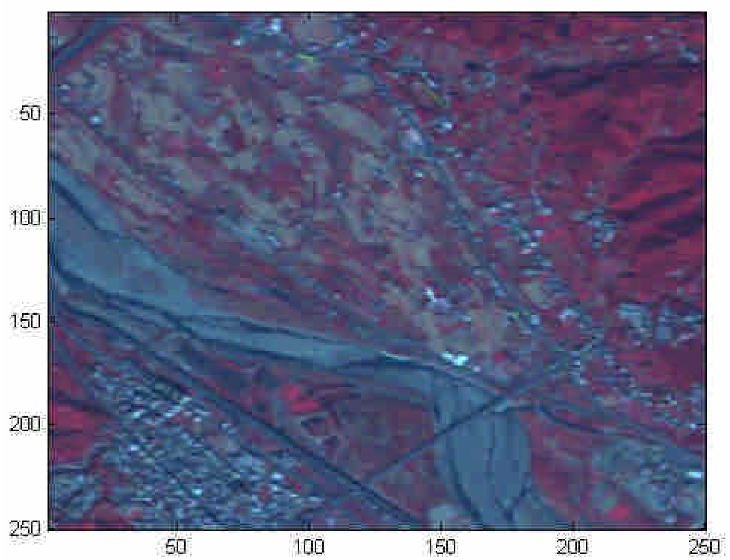


FIGURE 8-14. Image fusion using a color space transform (CST) and replacement of the intensity component. The multispectral image M has been previously registered to the high resolution image H.

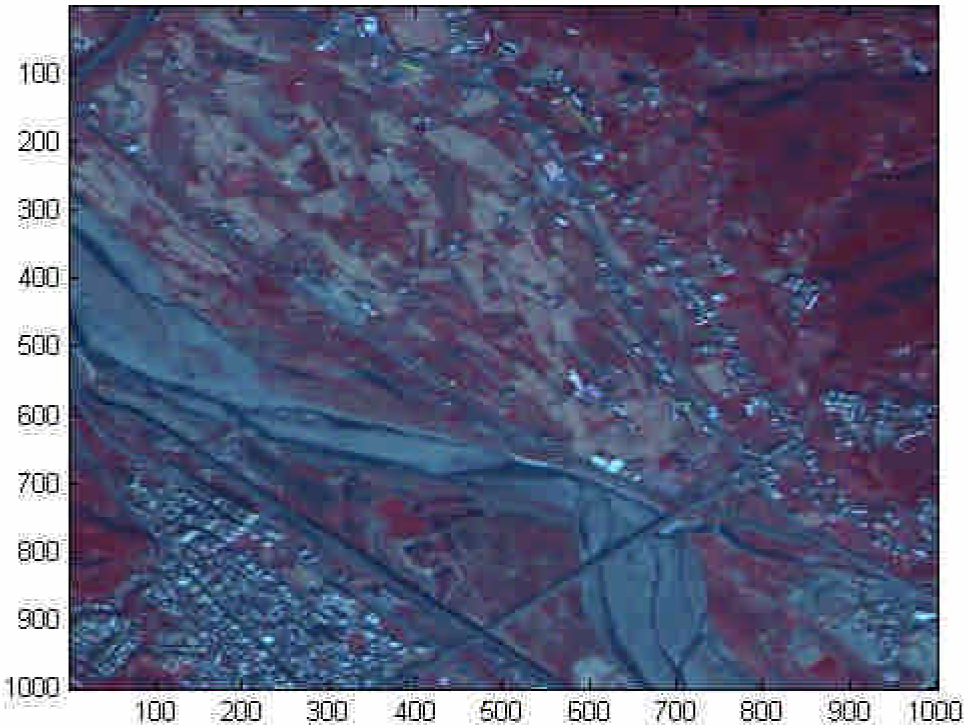
CST

```
load fusion_spot
imagesc(A)
colormap(gray)
figure
image(A1(:,:,[3 2 1]))
```



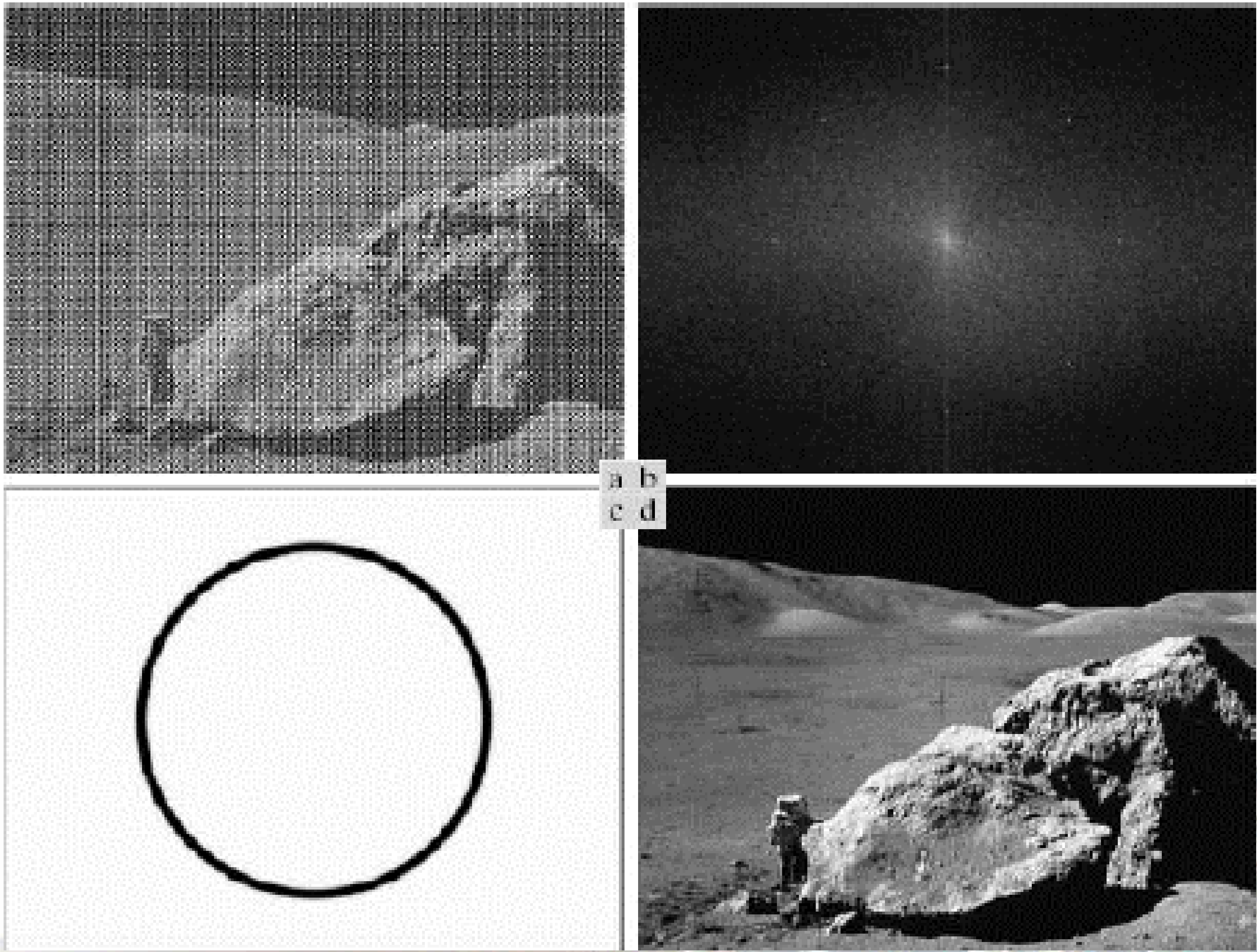


CST




```
C=rgb2hsv(B);
D=zeros(1000,1000,3);
for i=1:4,for j=1:4
   D(i:4:end,j:4:end,:)=C;
end,end
D(:,:,3)=double(A)/255;
F=hsv2rgb(D);
```

特殊雜訊分布濾波器



植生指數

Ratio Vegetation Index (RVI)

$$RVI = \frac{NIR}{R}$$

Normalized Difference Vegetation Index (NDVI)

$$NDVI = \frac{NIR - R}{NIR + R}$$

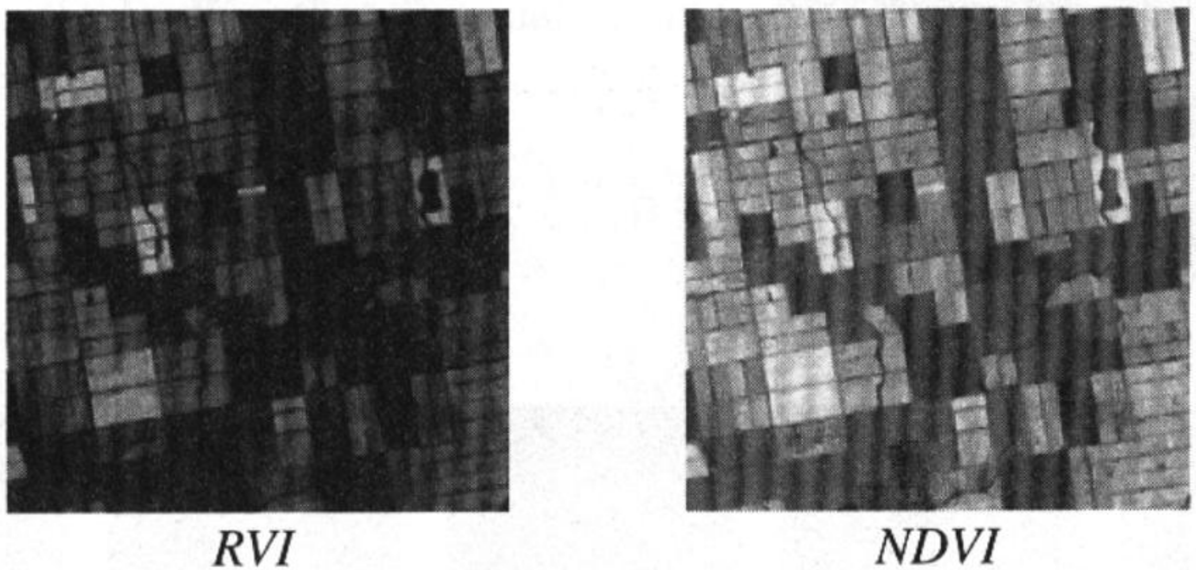


FIGURE 5-5. The RVI and NDVI index images for the TM agriculture image of Plate 5-1. Bands 4 and 3 were used and the indexes are calculated from uncalibrated DNs.

植生指數

Ratio Vegetation Index (RVI)

$$RVI = \frac{NIR}{R}$$

Normalized Difference Vegetation Index (NDVI)

$$NDVI = \frac{NIR - R}{NIR + R}$$

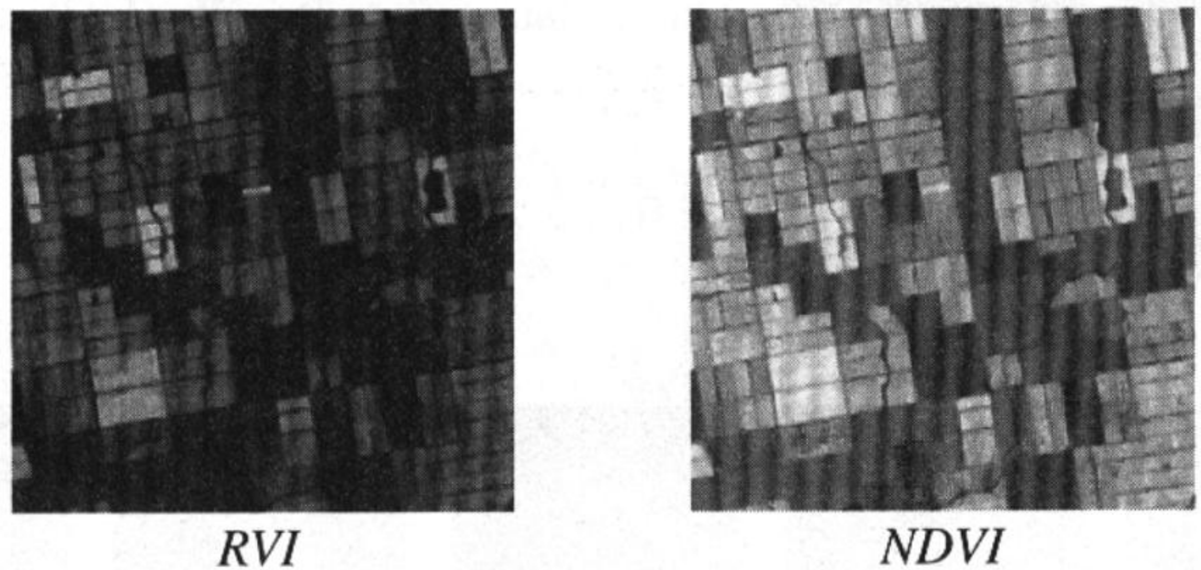
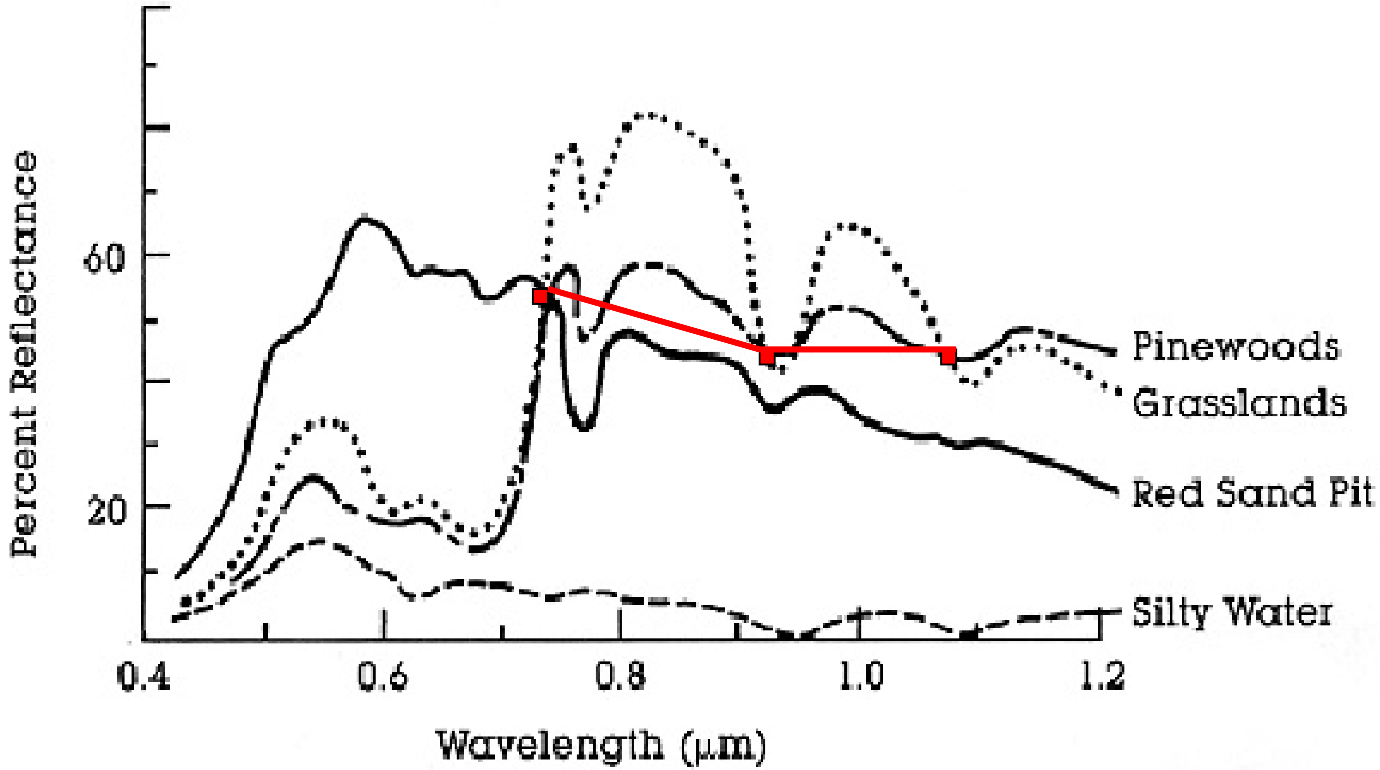


FIGURE 5-5. The RVI and NDVI index images for the TM agriculture image of Plate 5-1. Bands 4 and 3 were used and the indexes are calculated from uncalibrated DNs.

頻譜解析度



Percent Reflectance
60
20
0.4
0.6
0.8
1.0
1.2
Wavelength (μm)
Pinewoods
Grasslands
Red Sand Pit
Silty Water

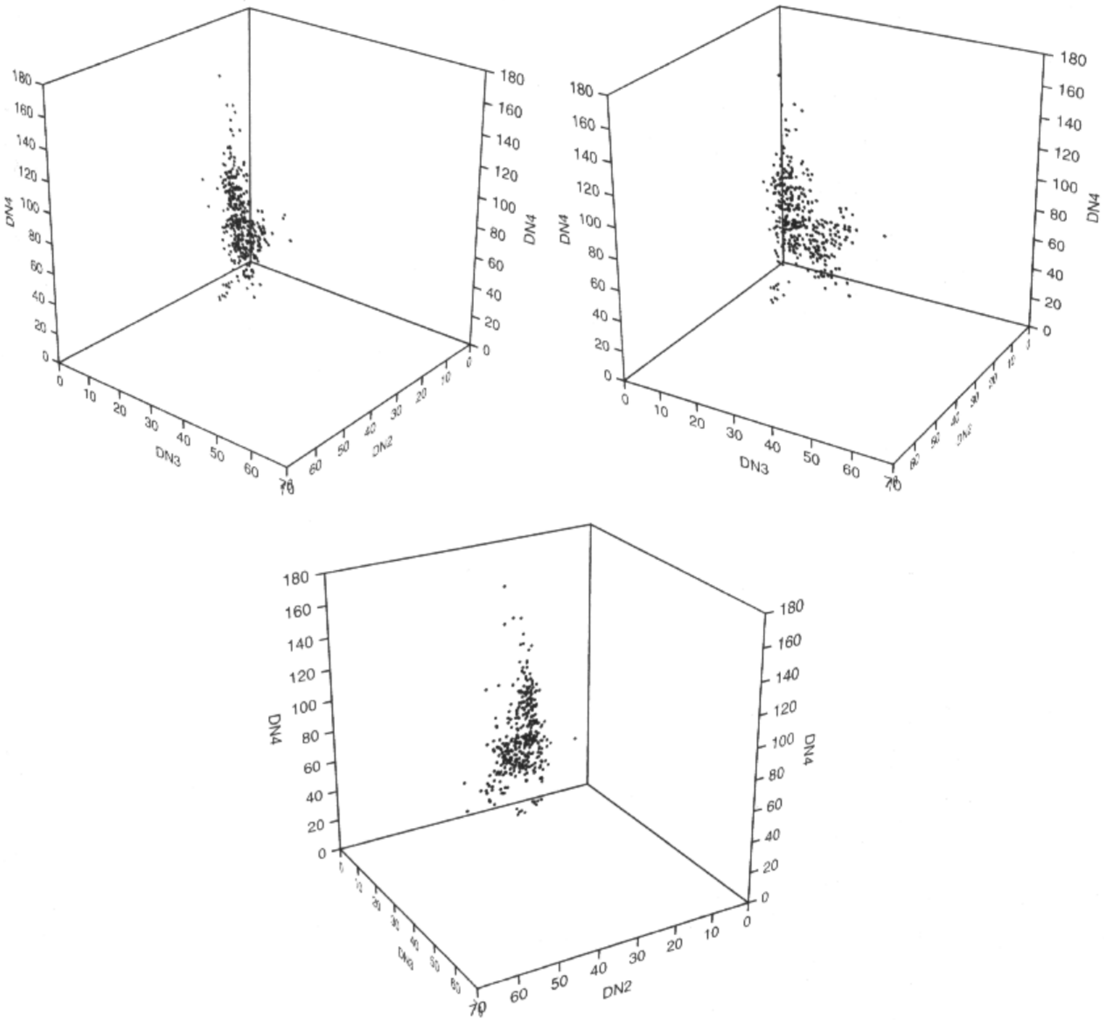


FIGURE 4-6. Three-band scatterplots of bands 2, 3 and 4 of a TM image, viewed from three different directions. Only every 20th sample and line of the image are used to calculate these scatterplots, so that they are not too dense. Every dot in the scatterplot represents one or more pixels with a particular spectral vector. Note that the image data occupies a small fraction of the total DN volume.

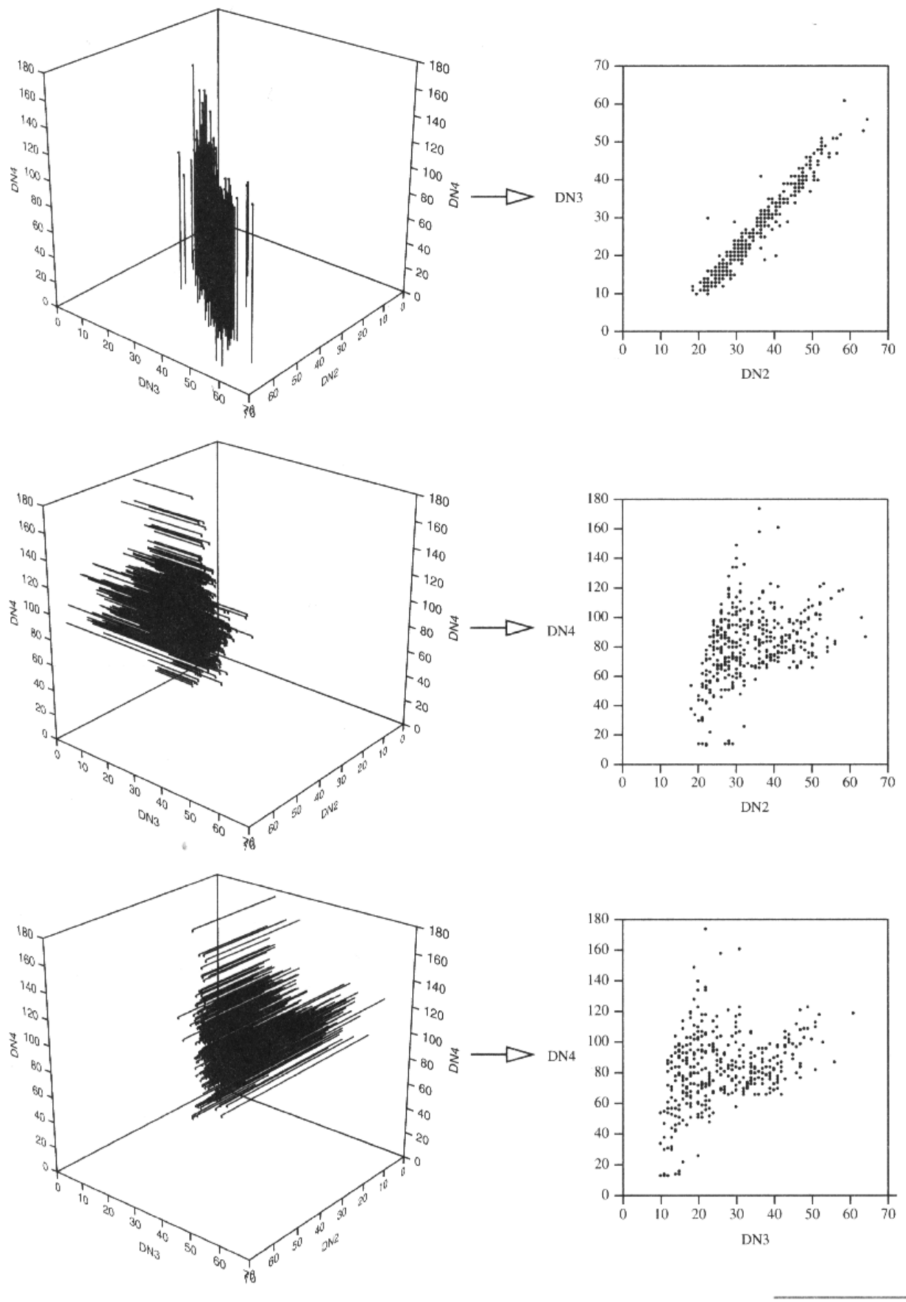


FIGURE 4-7. Reduction of 3-D scatterplots to 2-D scatterplots by projections onto the three bounding planes. The 2-D scatterplots provide multiple views of the data, but do not contain all the information that exists in 3-D.

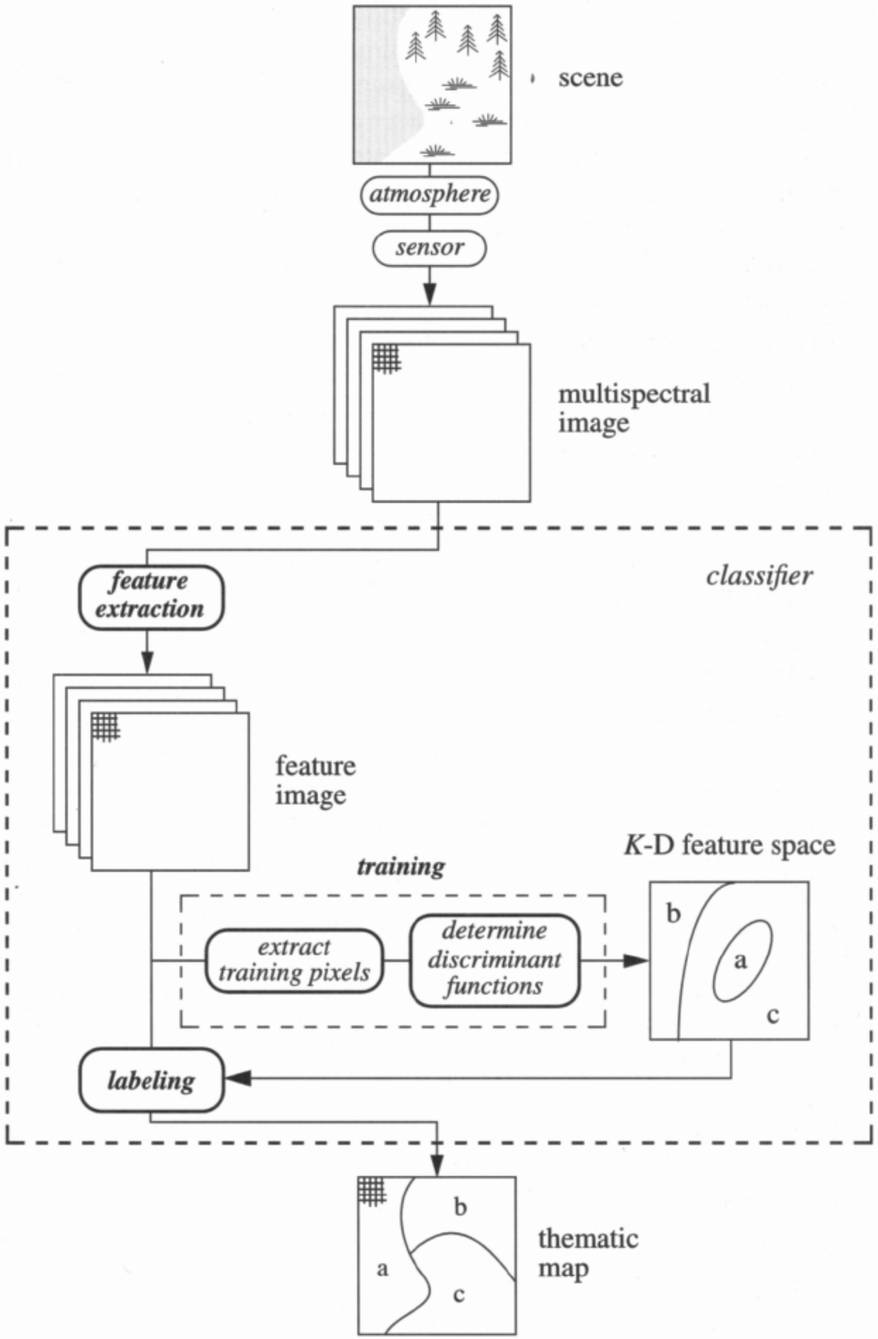


FIGURE 9-1. The data flow in a classification process.

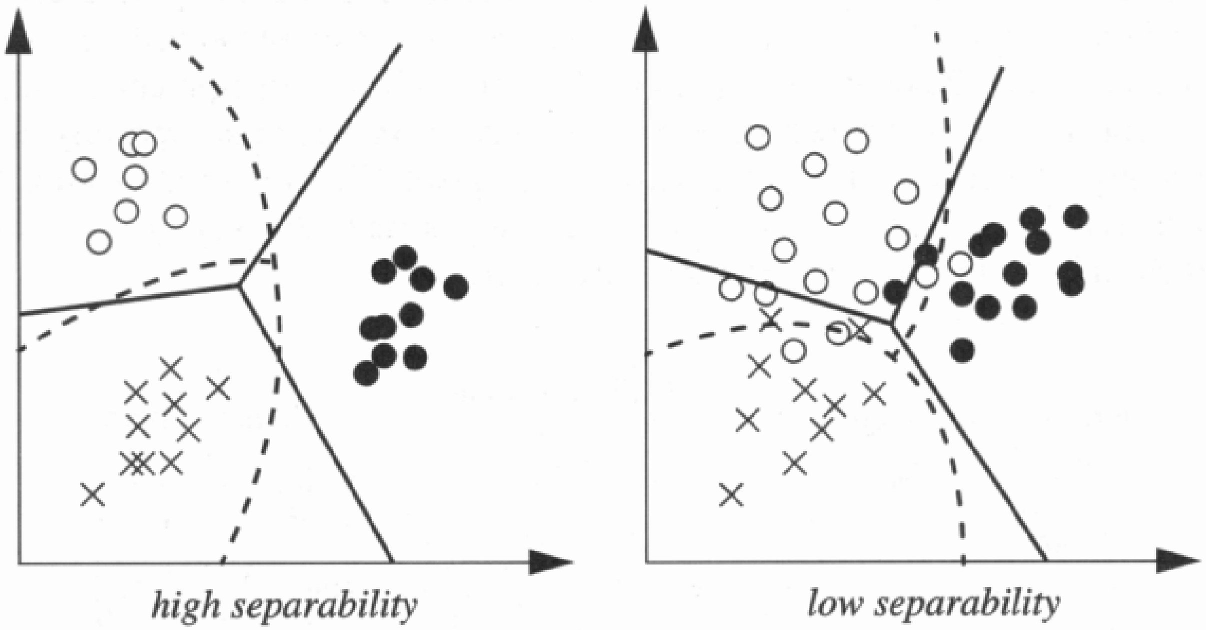


FIGURE 9-3. Two possible situations for training data in feature space and candidate decision boundaries. If the training classes are highly separable, there are many potential decision region partitions that can separate the classes without error; either the solid or dashed lines would do equally well. If the training data from different classes overlap, then a smooth decision boundary is impossible without misclassifications. The exact form of the decision boundary is then critical to the classification error.

假設我們的資料點是由維度爲m的向量X_i來表，其中 $i = 1,2,\ldots,n$

假設這一組資料的平均值是零：

$$\sum_{i=1}^{n} X_i = 0$$

目標是要找一個單位向量u，使得在u方向的投影平方和爲最大

用一個 $m \times n$ 矩陣A來表示此資料

$$A = \begin{bmatrix} X_1 & X_2 & X_3 & \cdots & X_n \end{bmatrix}$$

這一組資料在方向的投影可以表示爲下列向量：

$$p = \begin{bmatrix} X_1^T u \\ X_2^T u \\ \vdots \\ X_n^T u \end{bmatrix} = A^T u$$

投影平方的總和爲：

$$J(u) = \|p\|^2 = p^T p = \left(A^T u\right)^T \left(A^T u\right) = u^T A A^T u$$

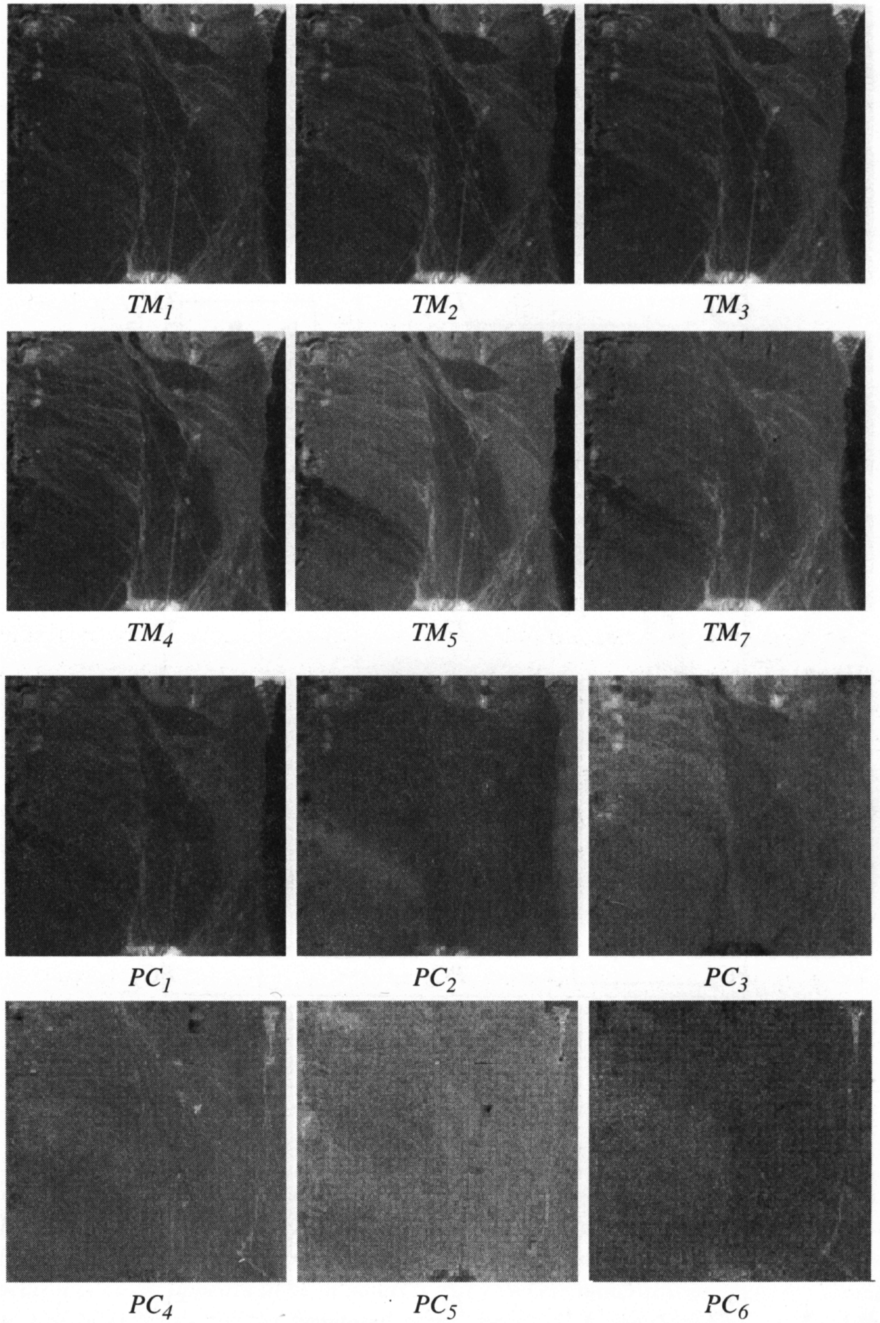
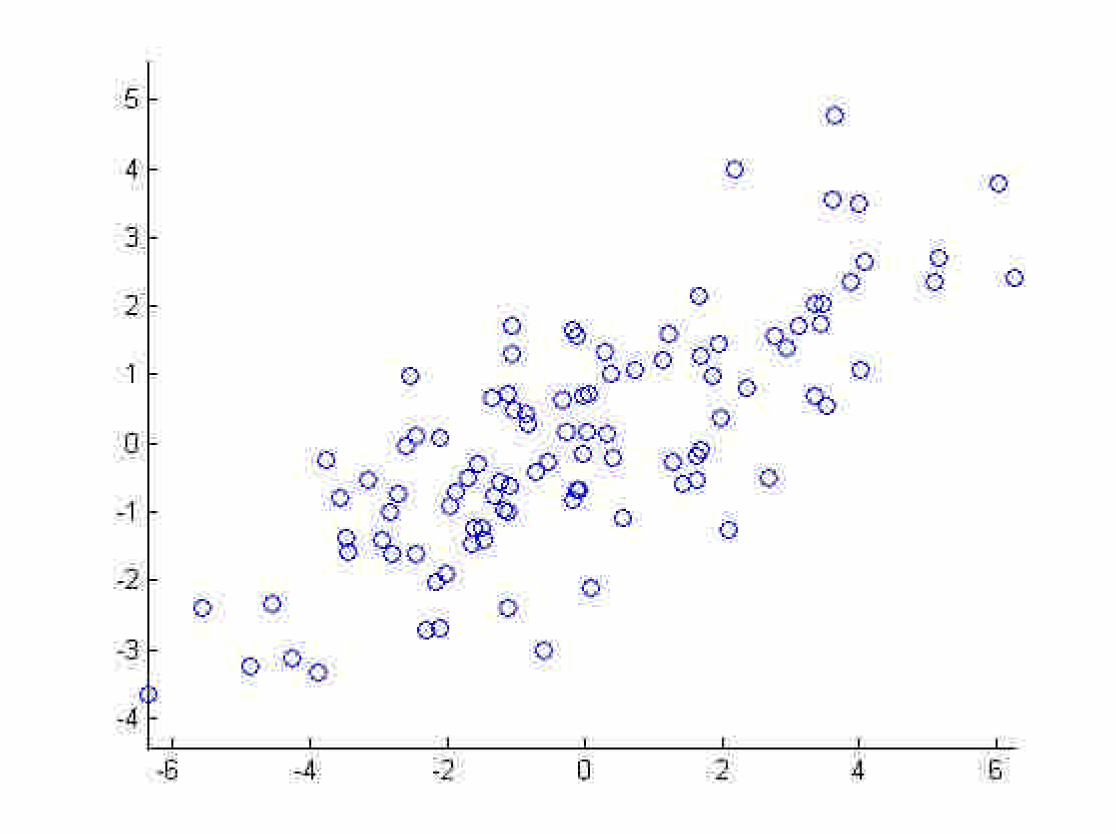
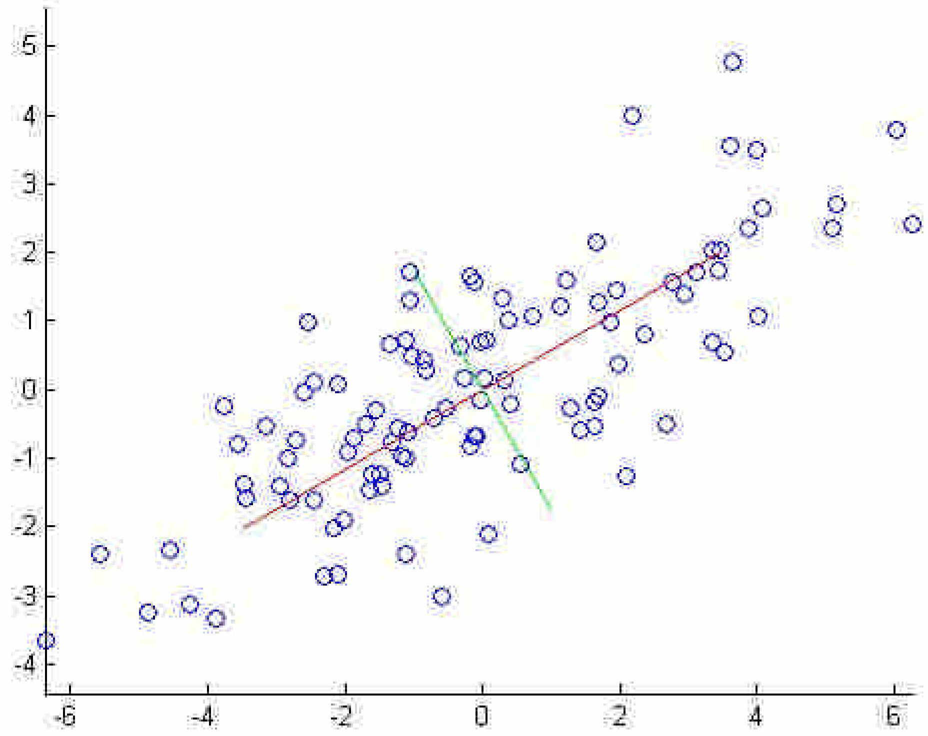


FIGURE 5-13. PC transformation of a nonvegetated TM scene.

Example



原始資料



兩各主軸方向