Chapter 6 Object Recognition

Part I   Pattern Matching

Object Recognition

Video of "cow tracking "

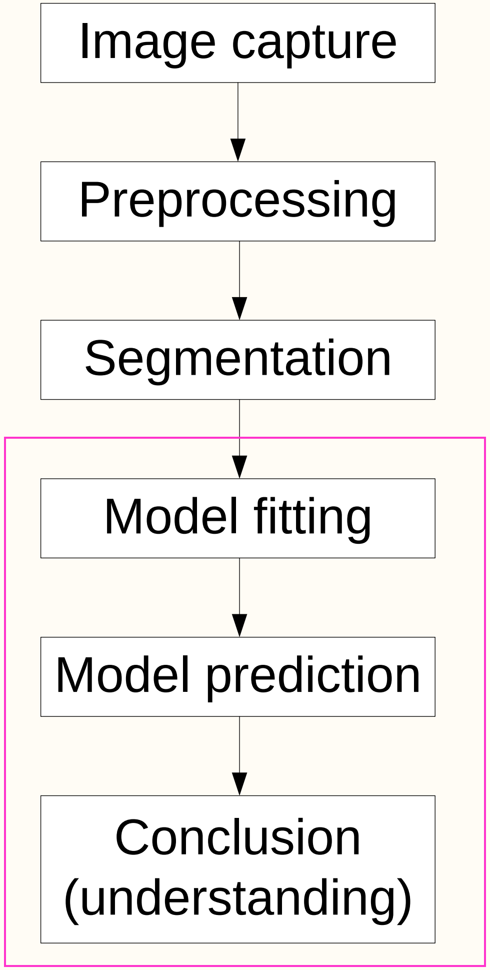


Fig. Flowchart of "cow tracking"

A Video

track.mpg

Image processing

+

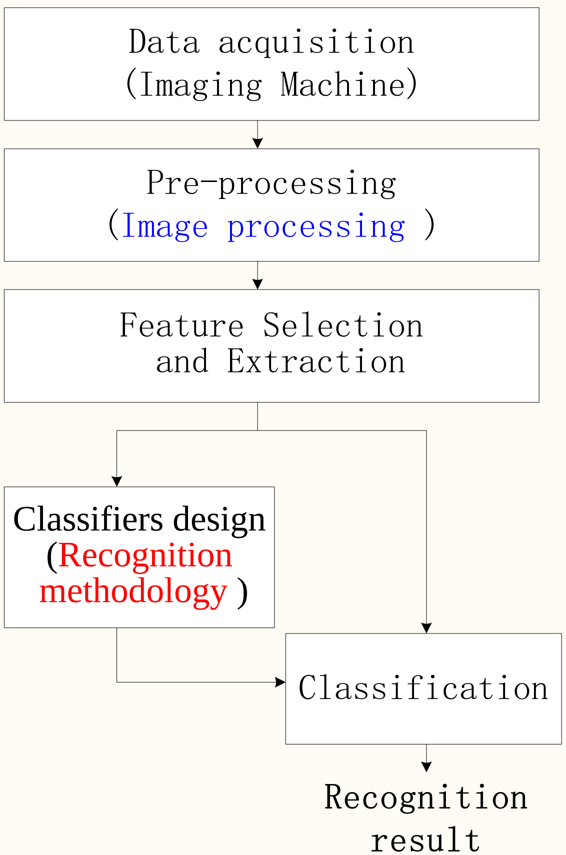
Image understanding !

Outline

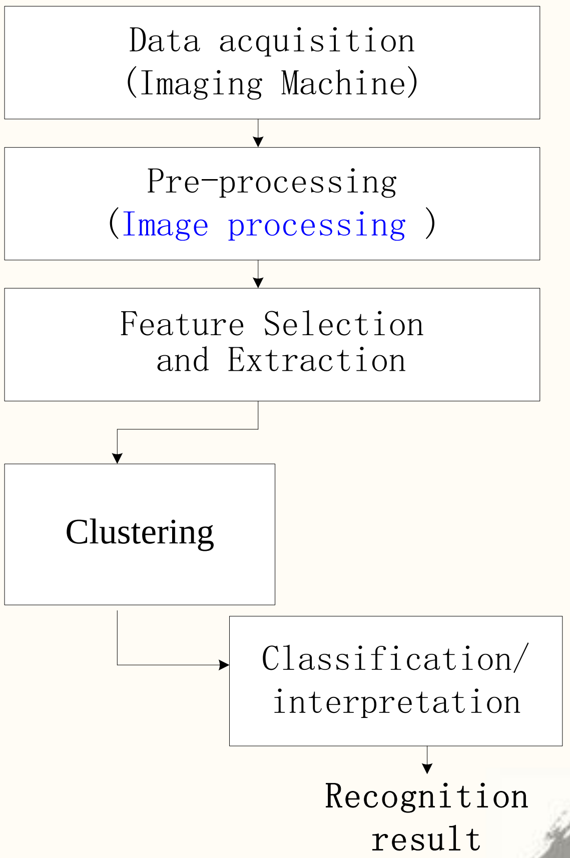
- 6.1 Pattern Recognition System
- 6.2 Feature Selection and Extraction
- 6.3 Pattern Matching
- 6.4 Linear and Nonlinear Classifiers
- 6.5 Clustering

Reference:
S. Theodoridis, K. Koutroumbas. Pattern Recognition (Fourth Edition). 2004

6.1 Pattern Recognition System



Supervised pattern recognition



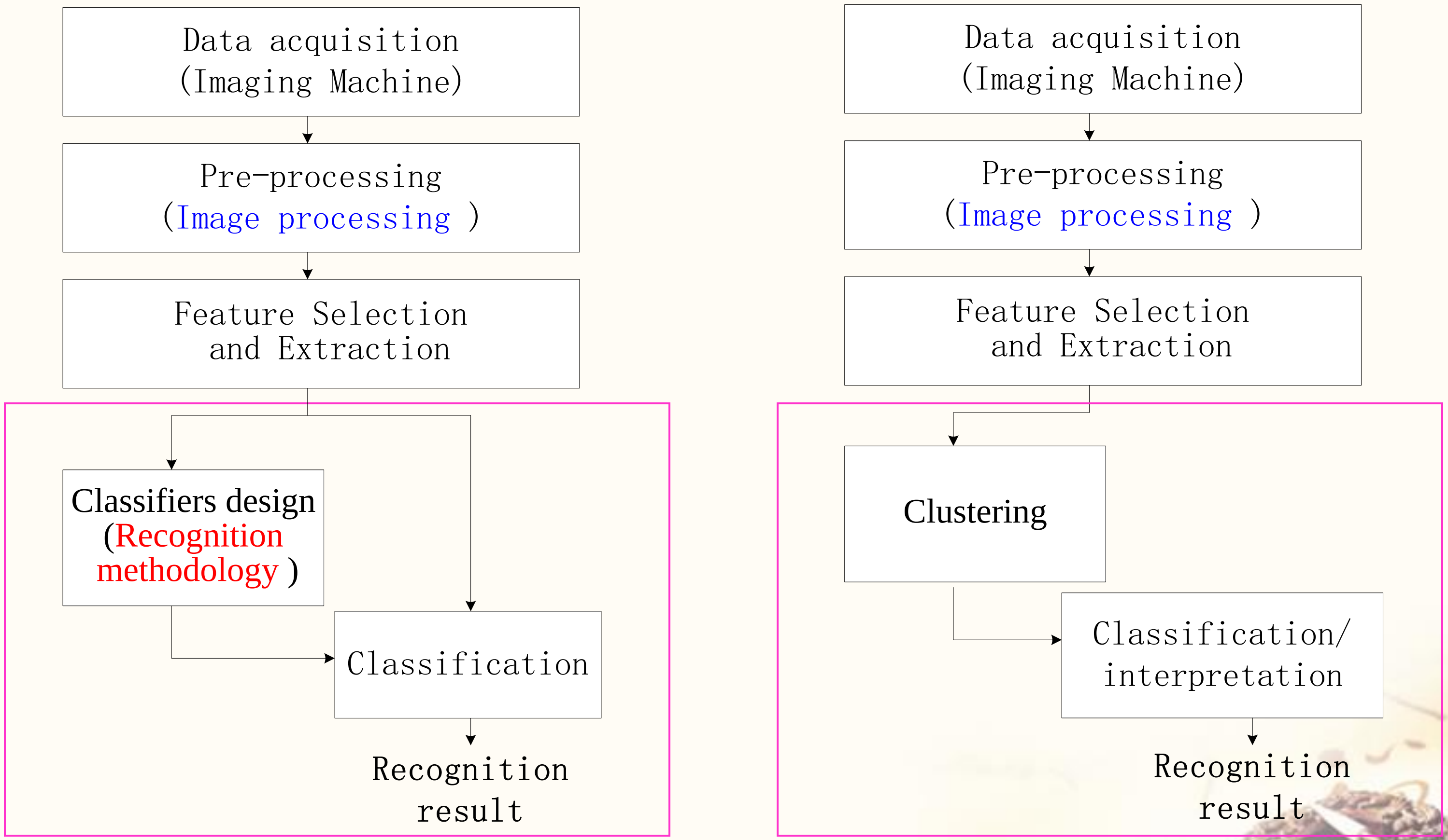
Unsupervised pattern recognition

Basic pattern recognition flowchart

6.2 Feature Selection and Extraction

1. Why "Features are important for object recognition?

Feature space!

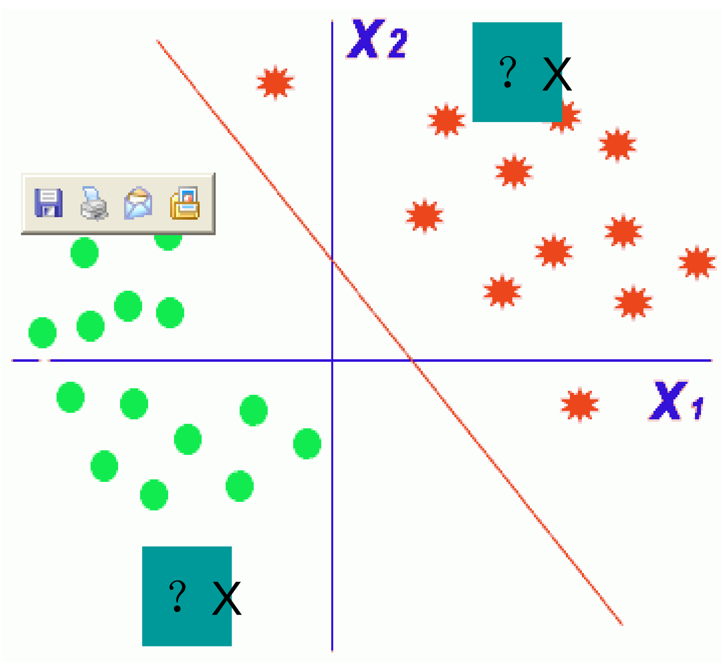


Feature space!

Supervised pattern recognition

Unsupervised pattern recognition

Pattern Recognition --- feature space



Feature Selection

1) skirts

2) secondary sex characteristic　　喉结 Adam's apple

3) 染色体 chromosome

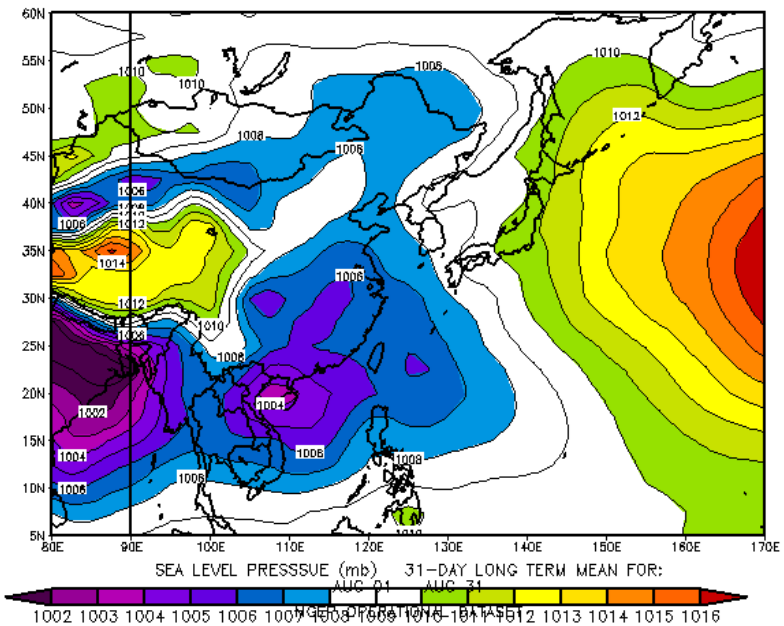
本页图片均来源于baidu搜索引擎

Feature Selection

- Shape features
- Texture features
- Color features
- Intensity features

For Machine Vision!

图像识别与图像特征



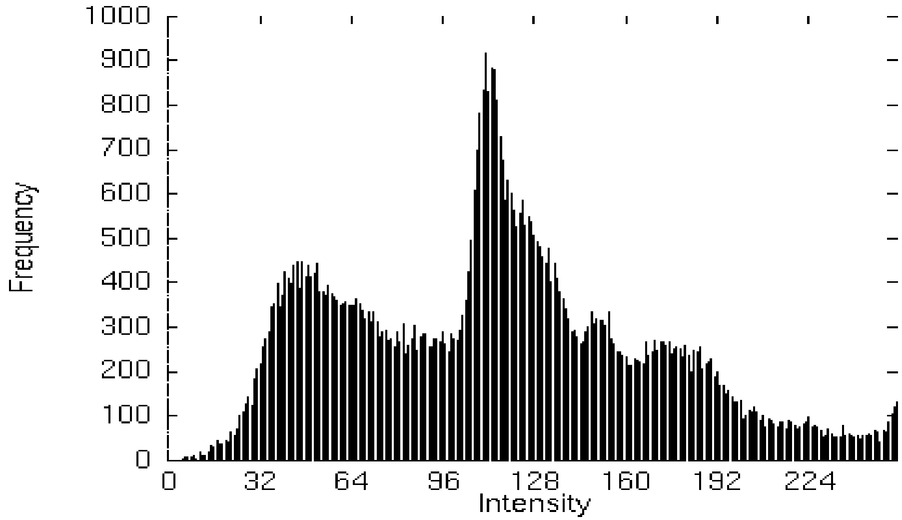


Figure 2.11 *A brightness histogram.*

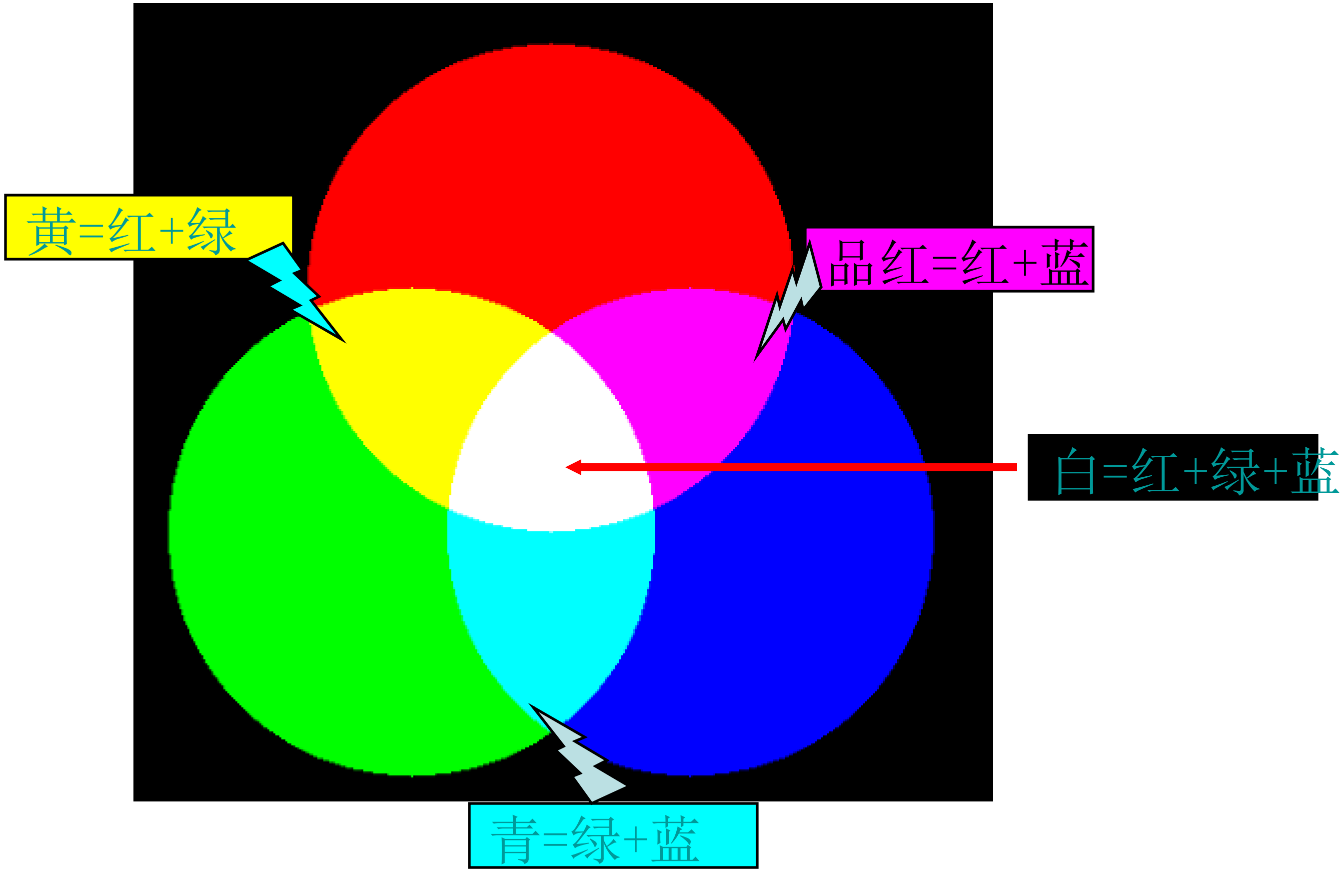
Color features

彩色模型

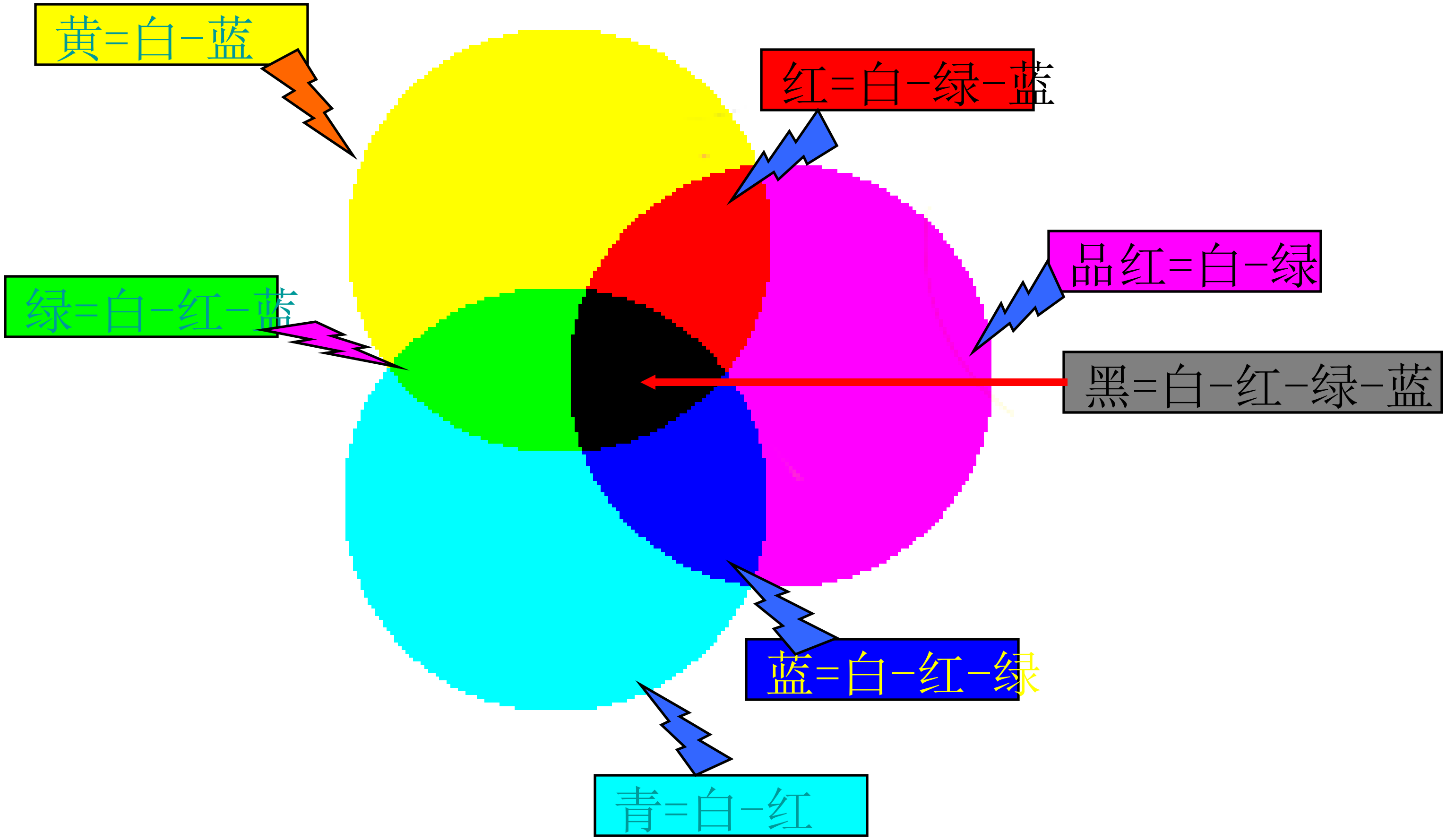
RGB 颜色空间、YIQ 颜色空间、
HSV 颜色空间、YCbCr 颜色空间

- **RGB模型**
- **HIS模型**
  H: hue 色相
  S: saturation 饱和度
  I: intensity 强度，明度
- **CMY系统 cyan, magenta , yellow**
  Secondary Colors 补色
- **CYMK系统 CYM+black**
- **Dithering 抖动， halftone 半色调**

RGB模型



CYM模型



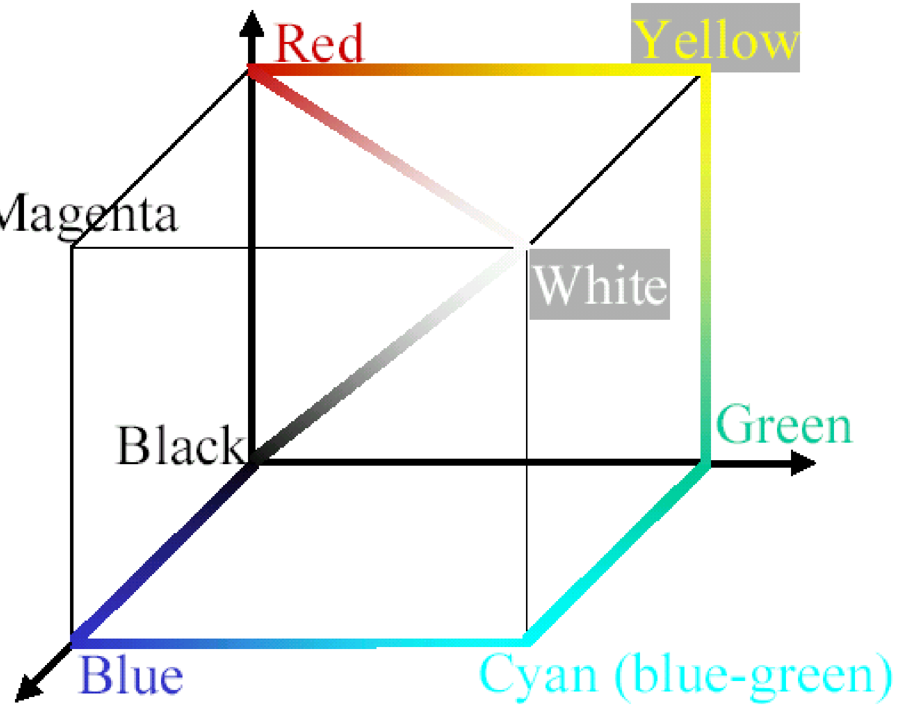
RGB与CYM模型的换算关系

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} W \\ W \\ W \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} W \\ W \\ W \end{bmatrix} - \begin{bmatrix} C \\ Y \\ M \end{bmatrix}$$

Hue Saturation and Brightness

RGB Color Cube



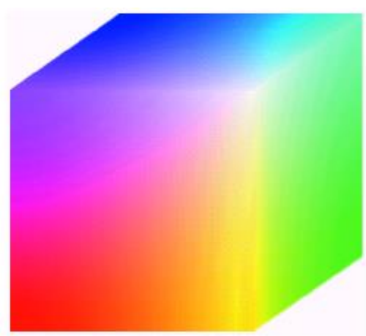
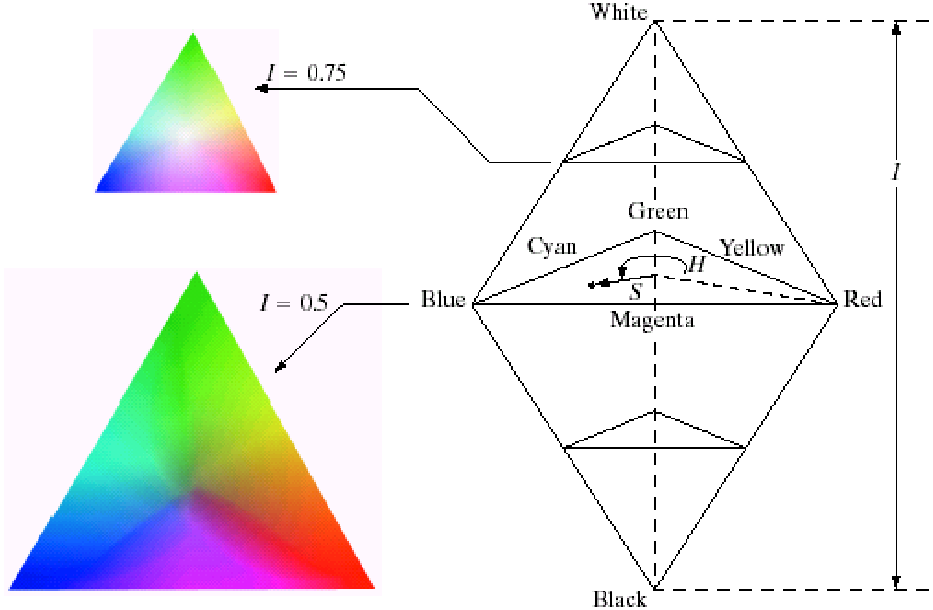
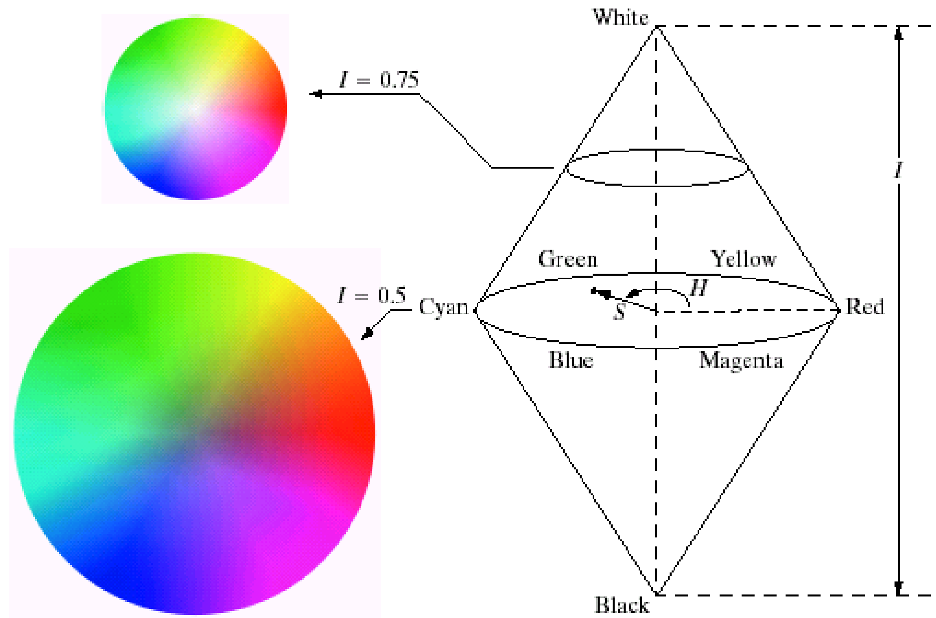


FIGURE 6.8 RGB 24-bit color cube.


White
I = 0.75
I
Green
Cyan
Yellow
H
S
I = 0.5
Blue
Red
Magenta
Black


White
I = 0.75
I
Green
Yellow
H
I = 0.5
Cyan
S
Red
Blue
Magenta
Black

相关文献表明[44~46]，肤色模型中 YCbCr 是较为常用的一种颜色空间。如前所述，YCbCr 颜色空间更符合人体视觉感受，并且它将没有很好体现肤色特征聚类性的亮度成分与色度信息分离出来，使得建立更加有效的肤色模型成为可能。

实验图来自《基于肤色的人脸检测以及人脸识别分类器改进_张齐》

图 2.7 装载测试

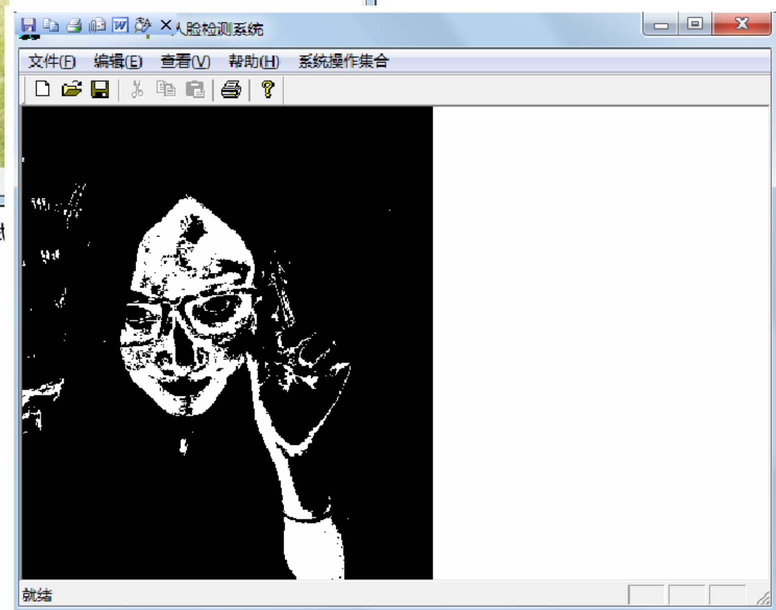


图 2.8 肤色建模后二值化效果图

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journal homepage: www.elsevier.com/locate/compag

Original papers

A visual navigation algorithm for paddy field weeding robot based on image understanding

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[a] School of Mechanical and Automotive Engineering, South China University of Technology, Guangzhou 510640, Guangdong, China
[b] School of Automation Science and Engineering, South China University of Technology, Guangzhou 510640, Guangdong, China

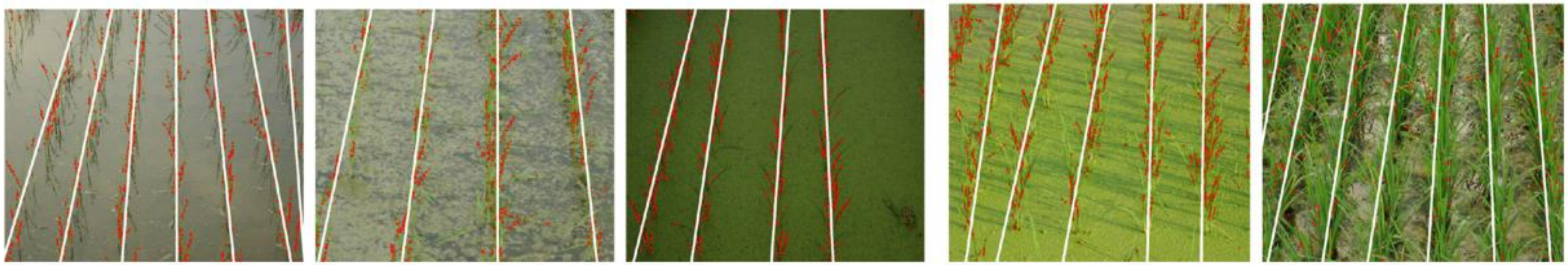


Fig. 15. The fitting of navigation line by applying Hough Transformation based on the known points.

Fig. 16. The test of vision navigation on the simulative paddy field environment.

Shape features

•Shape Representation and Description”

Reference:

1. S. Theodoridis, K. Koutroumbas. Pattern Recognition (Fourth Edition). 2004, pp.411- pp.463

2. Sonka et al. “Image Processing Analysis, and Machine Vision,” Third Edition. 2007, pp.328 – pp.373

Moments:

$$m_i = E[I^i] = \sum_{I=0}^{N_g-1} I^i P(I), \quad i = 1, 2, \ldots \tag{7.2}$$

Obviously $m_0 = 1$ and $m_1 = E[I]$, the mean value of I.

Central moments:

$$\mu_i = E[(I - E[I])^i] = \sum_{I=0}^{N_g-1} (I - m_1)^i P(I) \tag{7.3}$$

The most frequently used central moments are μ_2, μ_3, and μ_4. $\mu_2 = \sigma^2$ is the variance, and μ_3 is known as the *skewness* (sometimes and is normalized by σ^3) and μ_4 as the *kurtosis* (sometimes is normalized by σ^4) of the histogram. The vari-

μ_3 :	587	0	−169	169	0	0
μ_4 :	16609	7365	7450	7450	9774	1007

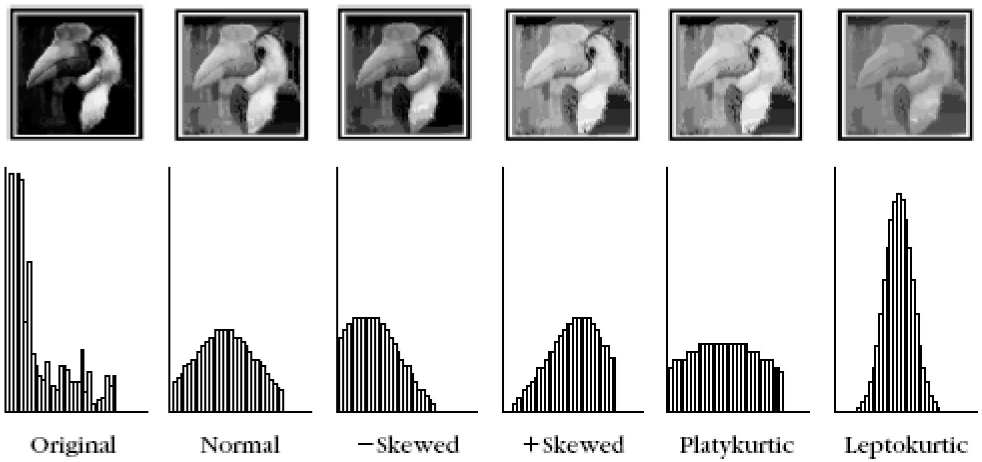


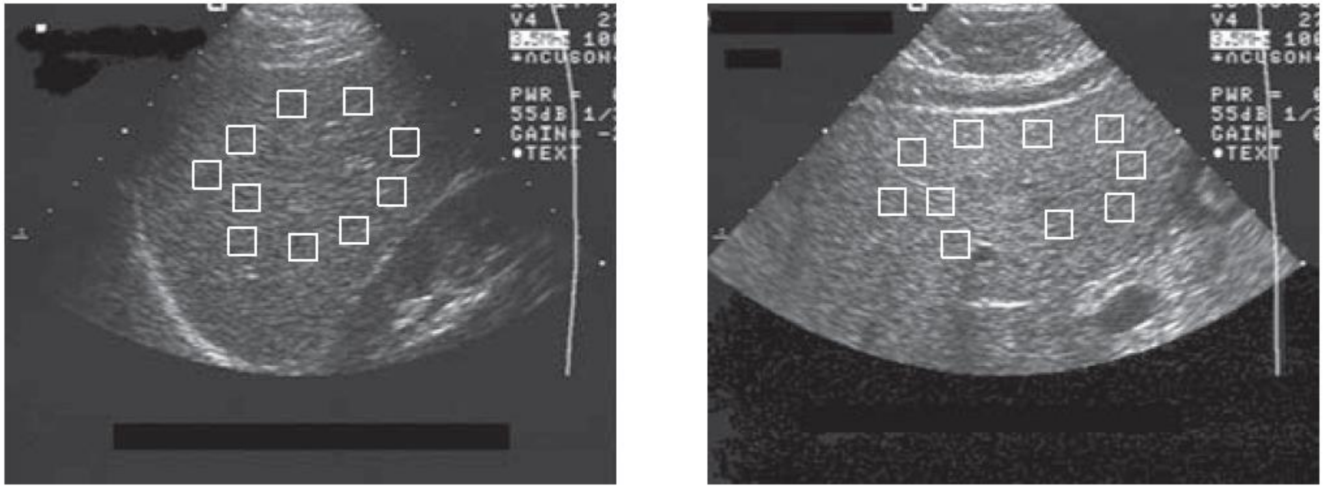
FIGURE 7.1

Examples of images and corresponding histograms.

方差

偏斜度：
平均值周围的直方图不对称性的度量

峰度：
直方图锐度的度量。
大值，低峰态；
小值，尖峰态；
其他常峰态



(a) (b)

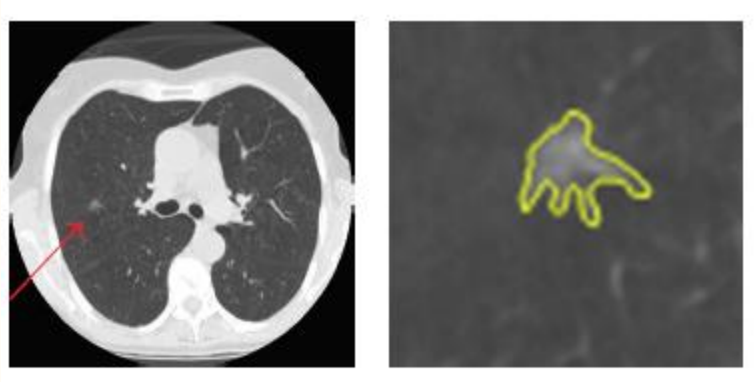
FIGURE 4.3

Selected ROIs from (a) cirrhotic liver and (b) liver with fatty infiltration.

Table 4.3 Features Calculated from 10 ROIs in Images of Cirrhotic and Fatty Liver Types

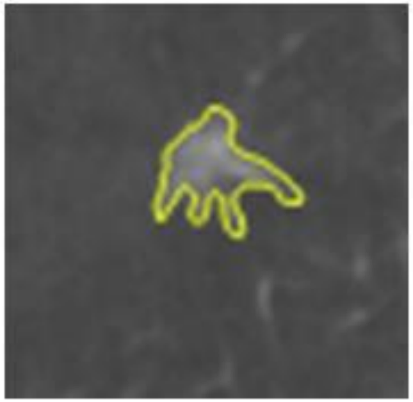
Cirrhotic Liver				Fatty Liver			
Mean	**Std**	**Skew**	**Kurtosis**	**Mean**	**Std**	**Skew**	**Kurtosis**
73.73	20.72	0.19	2.38	100.85	24.83	1.11	6.27
77.84	22.07	0.32	3.10	111.77	26.31	0.19	2.29
78.43	19.47	0.53	3.37	114.13	25.89	0.06	2.45
70.56	19.65	0.41	2.91	98.67	20.61	0.24	2.71
70.27	20.81	0.78	3.95	96.96	20.78	0.32	2.46
71.91	16.79	0.44	2.80	111.33	20.38	0.28	2.76
71.35	18.40	0.84	4.61	114.76	23.04	0.22	2.54
59.02	17.84	0.47	2.51	122.71	28.27	0.90	4.73
67.36	16.48	0.25	2.72	106.44	22.00	0.27	2.43
72.42	21.33	0.92	5.32	103.36	22.31	0.18	2.67

Texture features



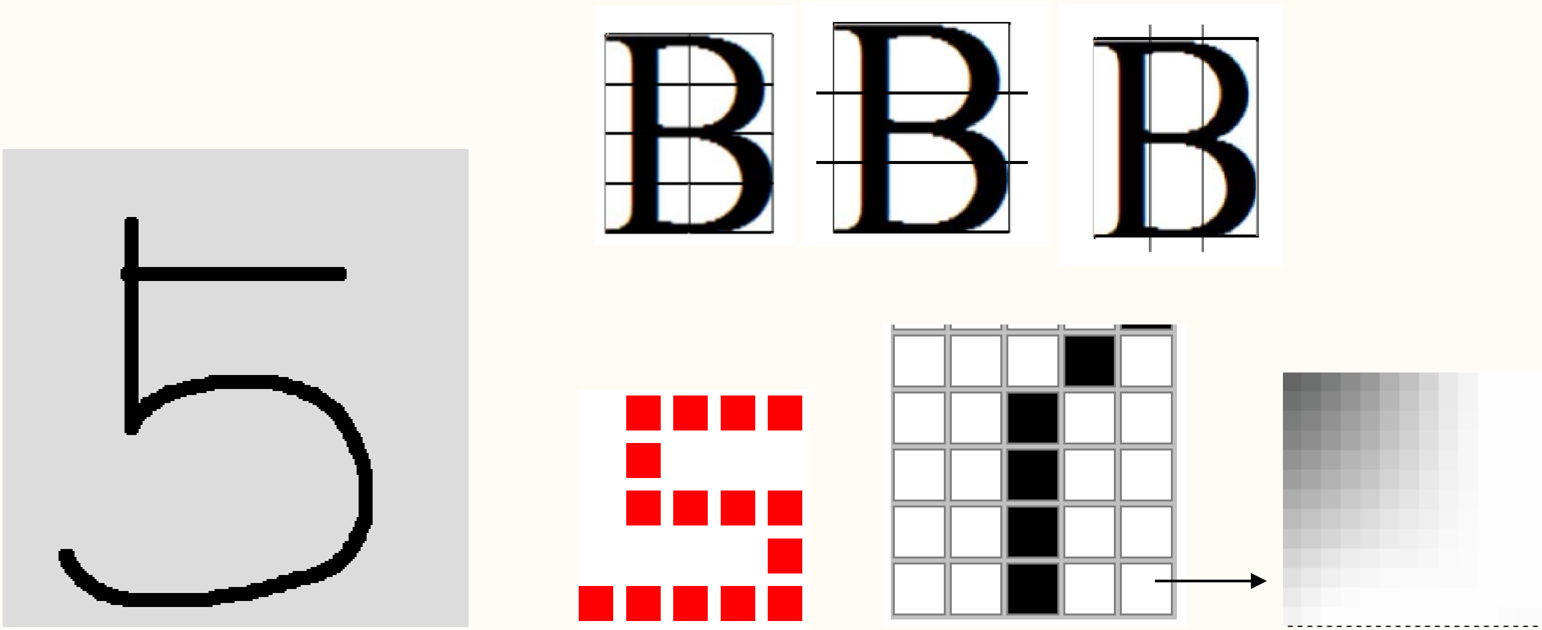
Texture	Energy, contrast, entropy, and adverse moment

纹理特征提取



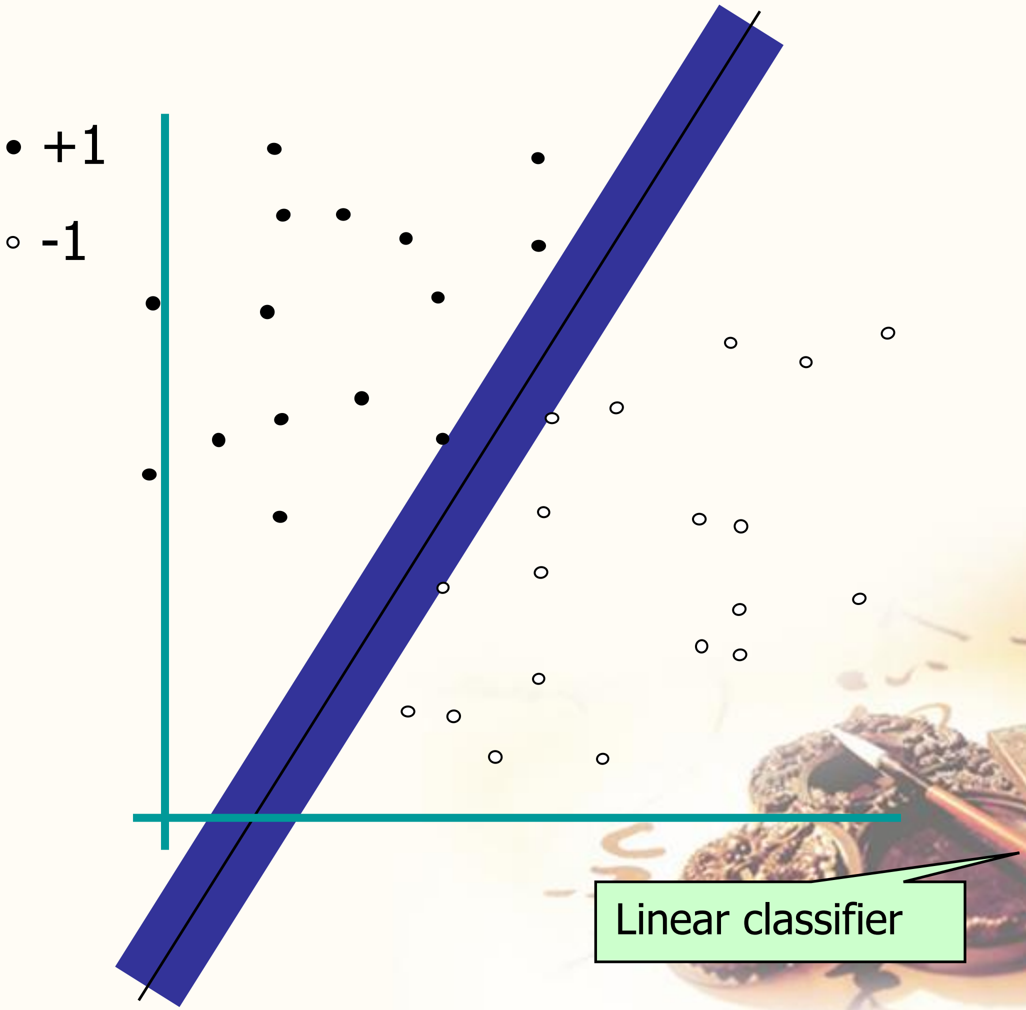
Texture	Energy, contrast, entropy, and adverse moment

Feature Representation



Feature Extraction

- KL Transform
- PCA
- ……



6.3 Pattern Matching

Minimum Distance Classifier

- Suppose that we define the prototype of each pattern class to be the mean vector of the patterns of that class:

$$m_j = \frac{1}{N_j} \sum_{x \in w_j} x_j \qquad \text{j=1,2,…,}W \qquad (1)$$

- Using the Euclidean distance to determine closeness reduces the problem to computing the distance measures

$$D_j(x) = \left\| x - m_j \right\| \qquad \text{j=1,2,…,}W \qquad (2)$$

Minimum Distance Classifier

- The smallest distance is equivalent to evaluating the functions

$$d_j(x) = x^T m_j - \frac{1}{2} m_j^T m_j \qquad \text{j=1,2,\ldots,}W \qquad (3)$$

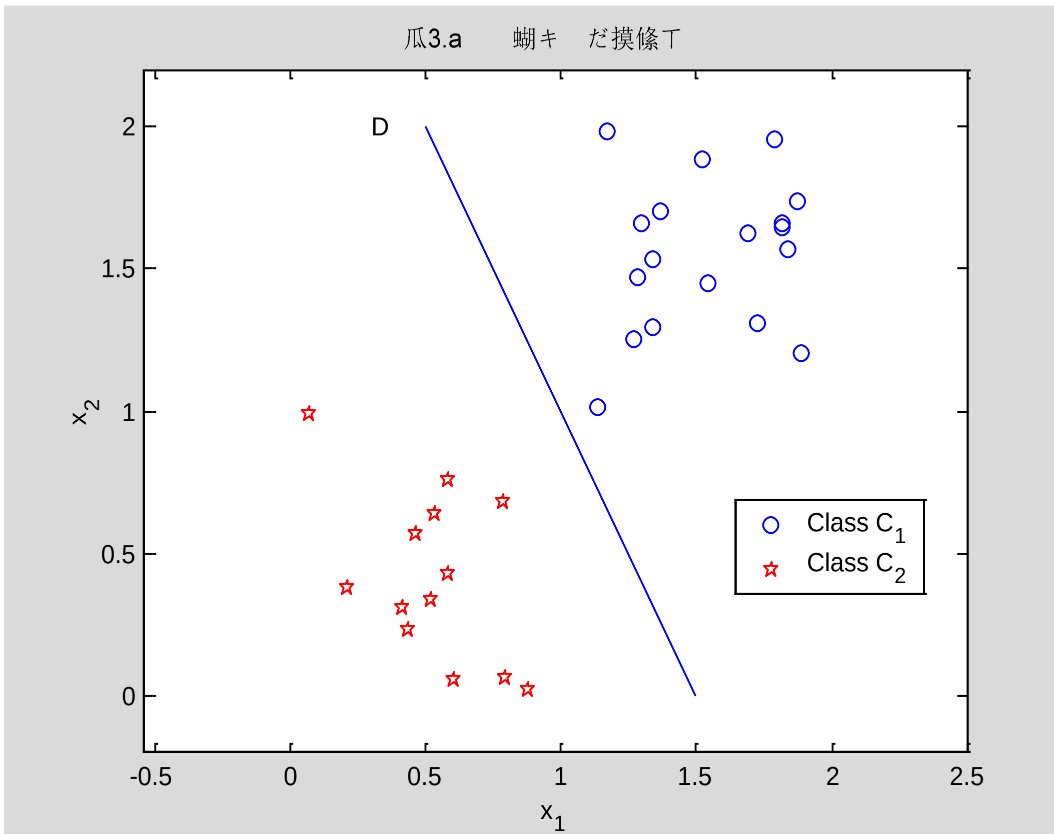
- The decision boundary between classes and for a minimum distance classifier is

$$d_{ij}(x) = d_i(x) - d_j(x) \qquad \text{j=1,2,\ldots,}W \qquad (4)$$

$$= x^T(m_i - m_j) - \frac{1}{2}(m_i - m_j)^T(m_i + m_j) = 0$$

Minimum Distance Classifier

- Decision boundary of minimum distance classifier



Minimum Distance Classifier

- Advantages:
  1. Unusual direct-viewing
  2. Can solve rotation the question
  3. Intensity
  4. Chooses the suitable characteristic, then solves mirror problem
  5. We may choose the color are one kind of characteristic, the color question then solve.

Minimum Distance Classifier

- Disadvantages:
  1. It costs time for counting samples, but we must have a lot of samples for high accuracy, so it is more samples more accuracy!
  2. Displacement
  3. It is only two features, so that the accuracy is lower than other methods.
  4. Scaling

Matching by Correlation

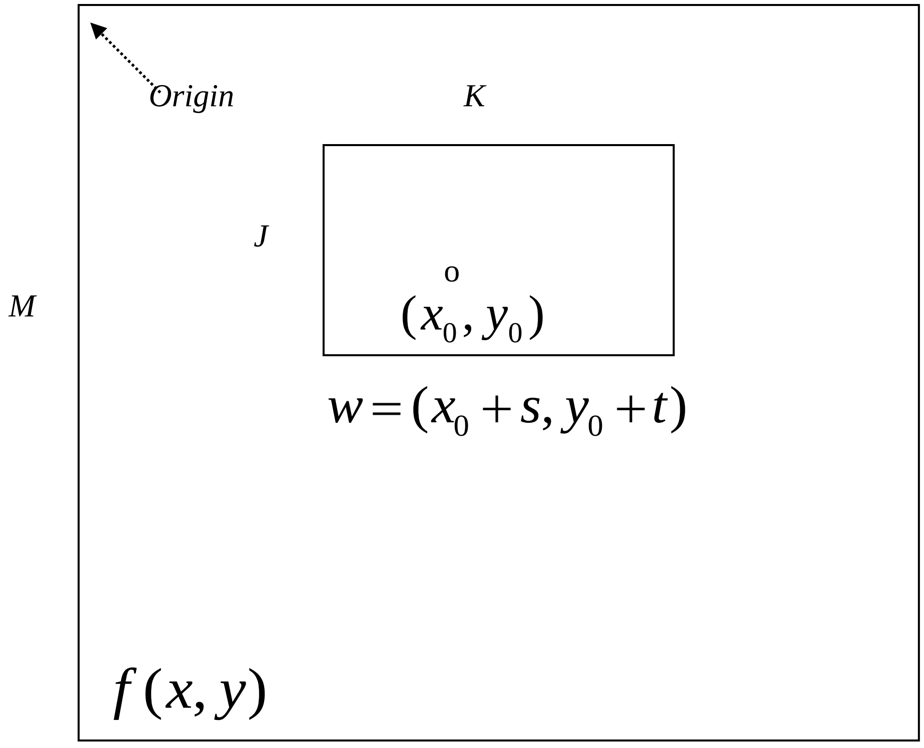
- We consider it as the basis for finding matches of a sub-image of size $J \times K$ within $f(x, y)$ an image of $M \times N$ size , where we assume that $J \leq M$ and $K \leq N$

$$c(x, y) = \sum_{s} \sum_{t} f(s, t) w(x + s, y + t)$$

for x=0,1,2,…,M-1,y=0,1,2,…,N-1 (5)

Matching by Correlation

- Arrangement for obtaining the correlation of f and w at point (x_0, y_0)



Matching by Correlation

- The correlation function has the disadvantage of being sensitive to changes in the amplitude of f and w
- For example, doubling all values of f doubles the value of $c(x, y)$
- An approach frequently used to overcome this difficulty is to perform matching via the *correlation coefficient*

$$\gamma(x,y) = \frac{\sum_s \sum_t [f(s,t) - \overline{f}(s,t)][w(x+s, y+t) - \overline{w}]}{\left\{ \sum_s \sum_t [f(s,t) - \overline{f}(s,t)]^2 \sum_s \sum_t [w(x+s, y+t) - \overline{w}]^2 \right\}^{\frac{1}{2}}}$$

- The correlation coefficient is scaled in the range-1 to 1, independent of scale changes in the amplitude of f and w

Matching by Correlation

- Advantages:
  1. Fast
  2. Convenient
  3. Displacement
- Disadvantages:
  1. Scaling
  2. Rotation
  3. Shape similarity
  4. Intensity
  5. Mirror problem
  6. Color can not recognition

Performance Assessment of Recognition Methods

Sensitivity and Specificity

	WITH DISEASE (D+)	WITHOUT DISEASE (D-)
TEST POSITIVE (T+)	TRUE POSITIVE (TP)	FALSE POSITIVE (FP)
TEST NEGATIVE (T-)	FALSE NEGATIVE (FN)	TRUE NEGATIVE (TN)

Sensitivity=TP/(TP+FN)

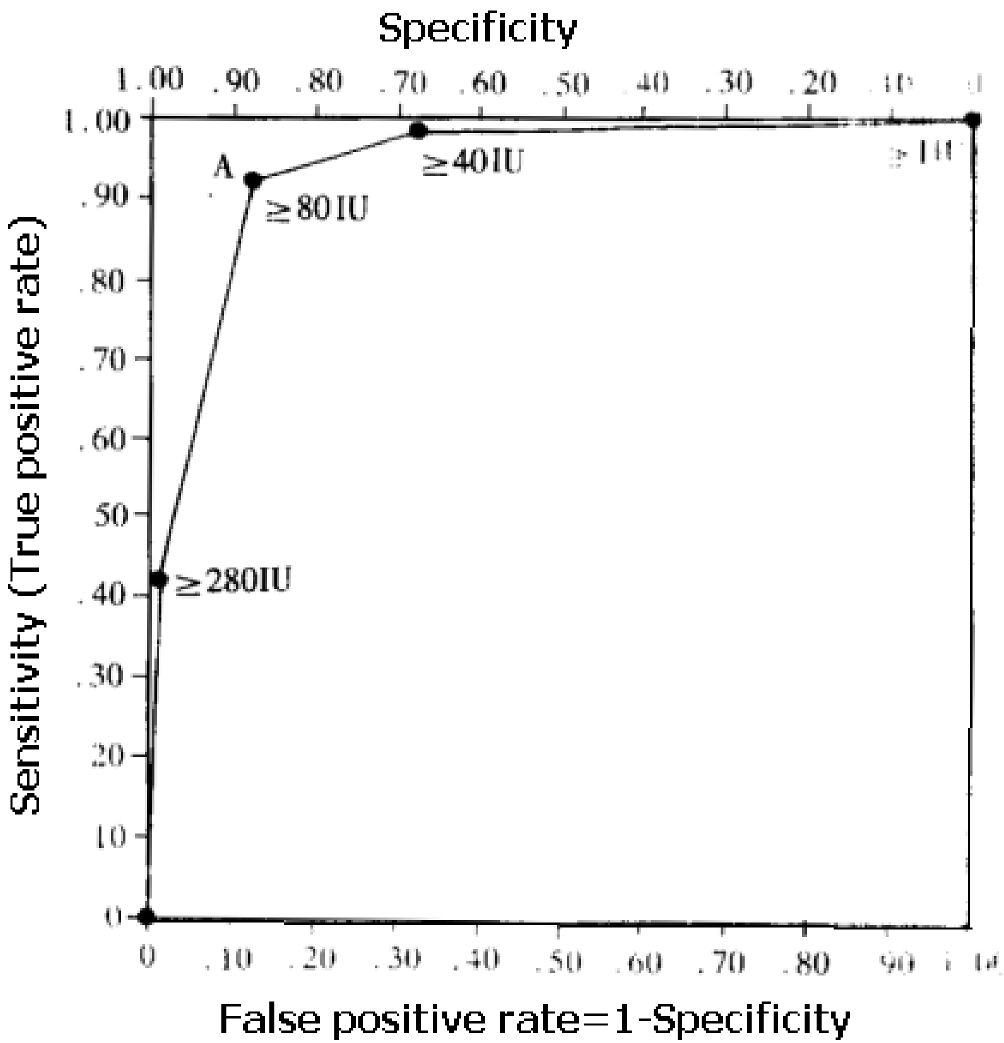
Specificity=TN/(TN+FP)

False negative rate (FNR)
=FN/(TP+FN)
=1-Sensitivity
=rate of missed diagnosis

False positive rate (FPR)
=FP/(TN+FP)
=1-Specificity
=misdiagnosis rate

Accuracy=(TP+TN)/N

Receive Operater Characteristic Curve (ROC curve)



Receive Operater Characteristic Curve (ROC curve)

AUC(area under ROC curves)

Knowledge points

- Pattern Recognition System
- Feature Selection and Extraction
- Pattern Matching

Questions and Practices

- 1)PLS Work hard to finish project 1 in time.

- 2)PLS think about how to recognize printed letter.