
VC 11/12 – T14

Visual Feature Extraction

Mestrado em Ciência de Computadores
Mestrado Integrado em Engenharia de Redes e
Sistemas Informáticos

Miguel Tavares Coimbra

Outline

- Feature Vectors
- Colour
- Texture
- Shape

Topic: Feature Vectors

- Feature Vectors
- Colour
- Texture
- Shape

Visual Features

The earth is blue,
white and
brown



The earth is round

The south pole has
a smooth texture

Visual Features

- **Features**
 - Measure specific characteristics.
 - Numerical values.
 - May have multiple values.
- **Visual Features**
 - Quantify visual characteristics of an image.
 - Popular features.
 - Colour, Texture, Shape

Feature vector

- Feature F_i $F_i = [f_i]$

- Feature F_i with N values.

$$F_i = [f_{i1}, f_{i2}, \dots, f_{iN}]$$

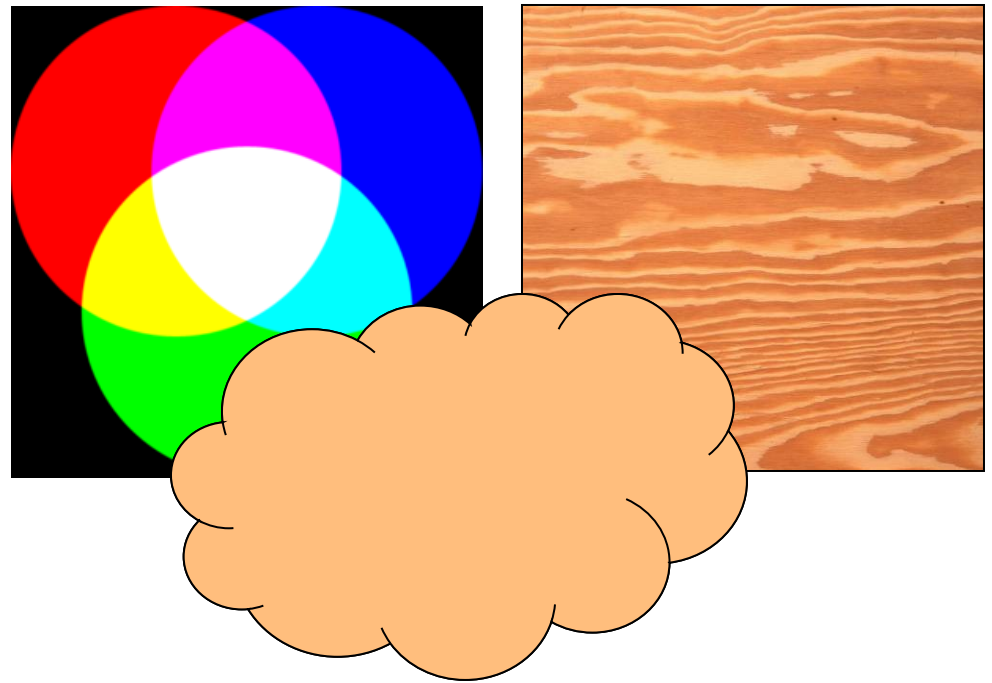
- Feature vector F with M features.

$$F = [F_1 | F_2 | \dots | F_M]$$

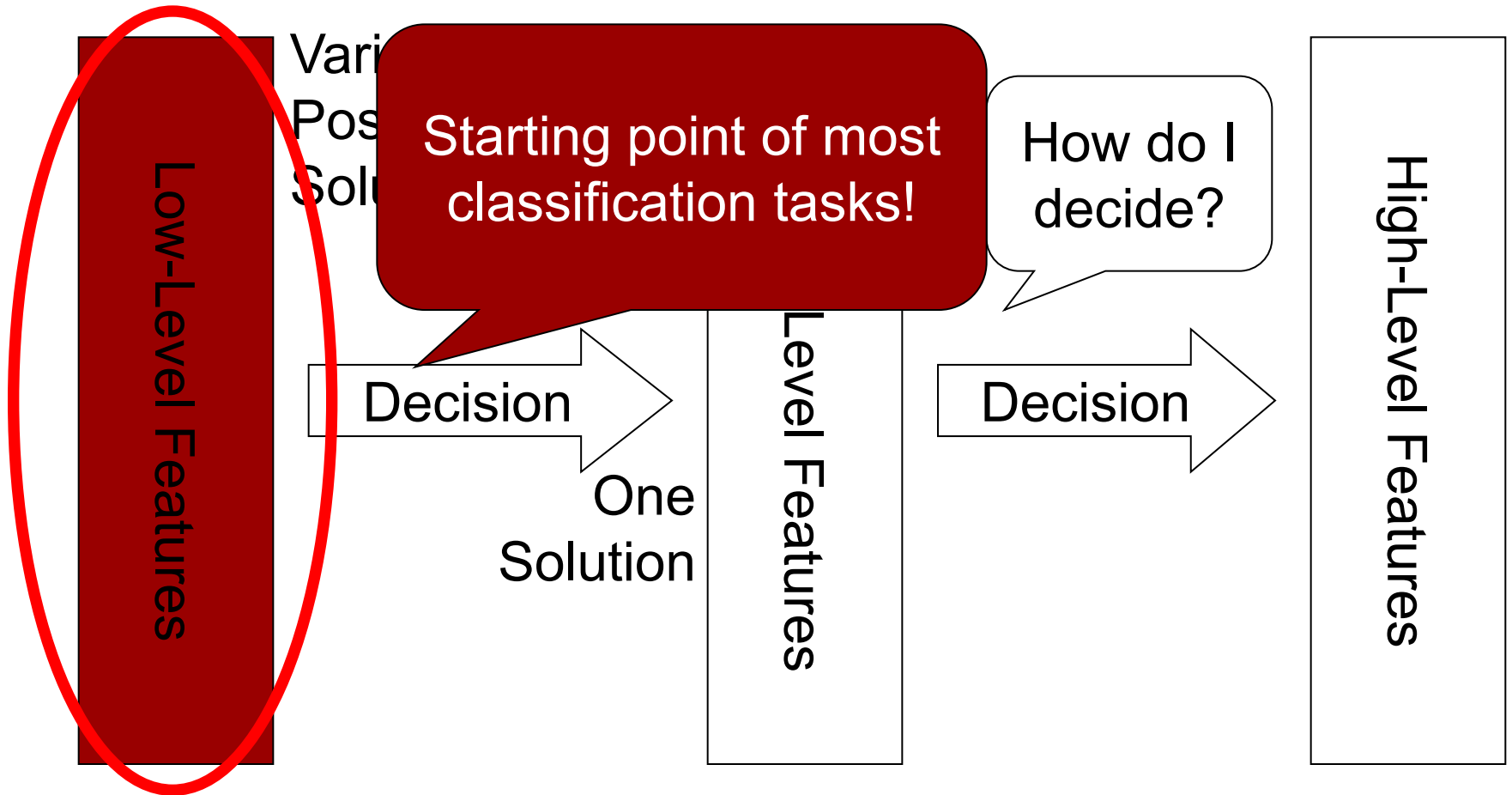
- Naming conventions for this module:
 - Elements of a **feature vector** are called **coefficients**.
 - **Features** may have one or more **coefficients**.
 - **Feature vectors** may have one or more **features**.

Low-level visual features

- Objective
- Directly reflect specific visual features.
 - Colour
 - Texture
 - Shape
 - Etc.



Features & Decisions



How to quantify visual features?

- Many possibilities!
- We need a standard.
- **MPEG-7 Standard**
 - Developed by the Moving Pictures Expert Group.
 - “is a standard for describing the multimedia content data that supports some degree of interpretation of the information meaning, which can be passed onto, or accessed by, a device or a computer code”

*[MPEG-7 Overview (version 10),
ISO/IEC JTC1/SC29/WG11N6828]*

The MPEG-7 standard

- Provides a rich set of standardized tools to describe multimedia content.
 - Computer annotation.
 - Human annotation.
- **Audiovisual Description Tools**
 - Descriptors
 - Descriptor Schemes
- **Target functionality:**
 - Efficient search, filtering and browsing of multimedia content.



Feature Vectors

MPEG-7 Links

- MPEG website
<http://www.chiariglione.org/mpeg>
- MPEG-7 Industry Forum website
<http://www.mpegif.com>
- MPEG-7 Consortium website
<http://mpeg7.nist.gov>
- MPEG-7 Overview (version 10)
<http://www.chiariglione.org/mpeg/standards/mpeg-7/mpeg-7.htm#E9E3>

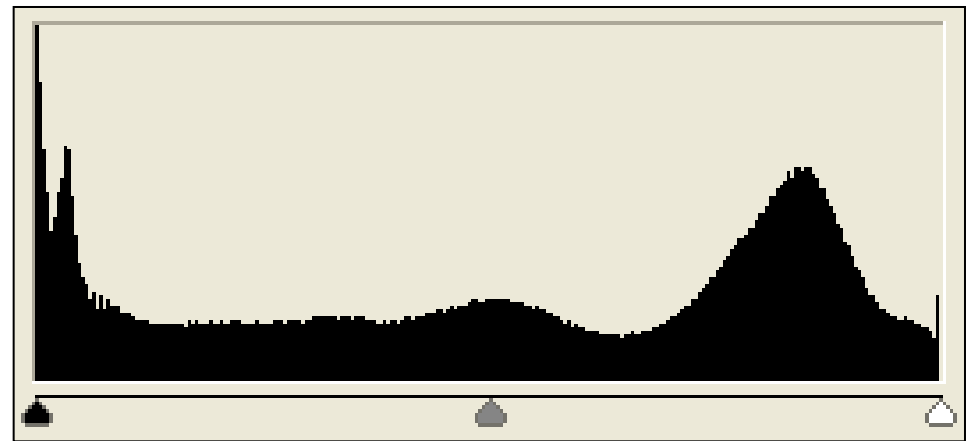
Topic: Colour

- Feature Vectors
- **Colour**
- Texture
- Shape

Gray-Level Histogram

- Intensity distribution (HSI).
- We can define the number of histogram bins.
- Histogram bins = Feature coefficients.

$$F = [f_0, \dots, f_{255}]$$



Colour Histogram

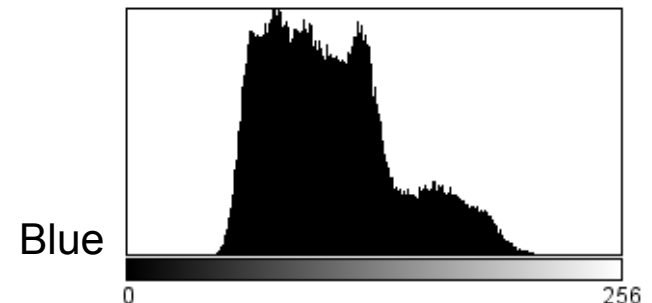
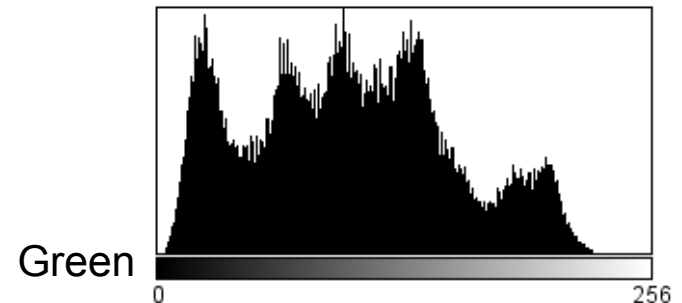
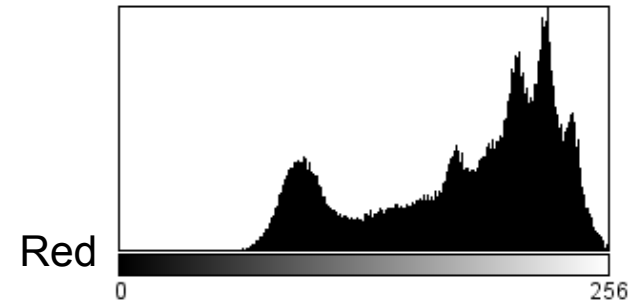
- We typically have three histograms

Ex: RGB Colour space

- Red Histogram
- Green Histogram
- Blue Histogram

- How do we build a feature vector?

- Concatenate vectors.
- Multi-dimensional quantization of colour space.



RGB Histogram

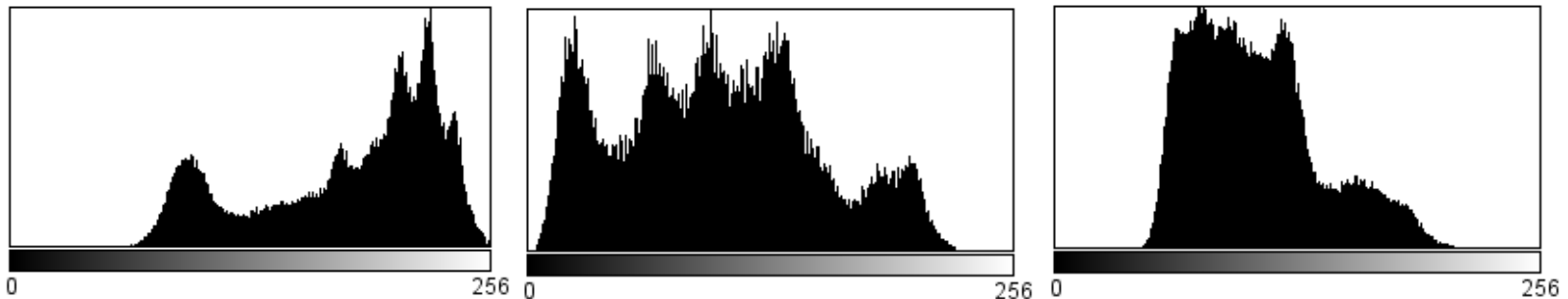
- Simply concatenate vectors.
- Not very smart. (why?)

$$F_R = [f_{R0}, \dots, f_{R255}]$$

$$F_G = [f_{G0}, \dots, f_{G255}]$$

$$F_B = [f_{B0}, \dots, f_{B255}]$$

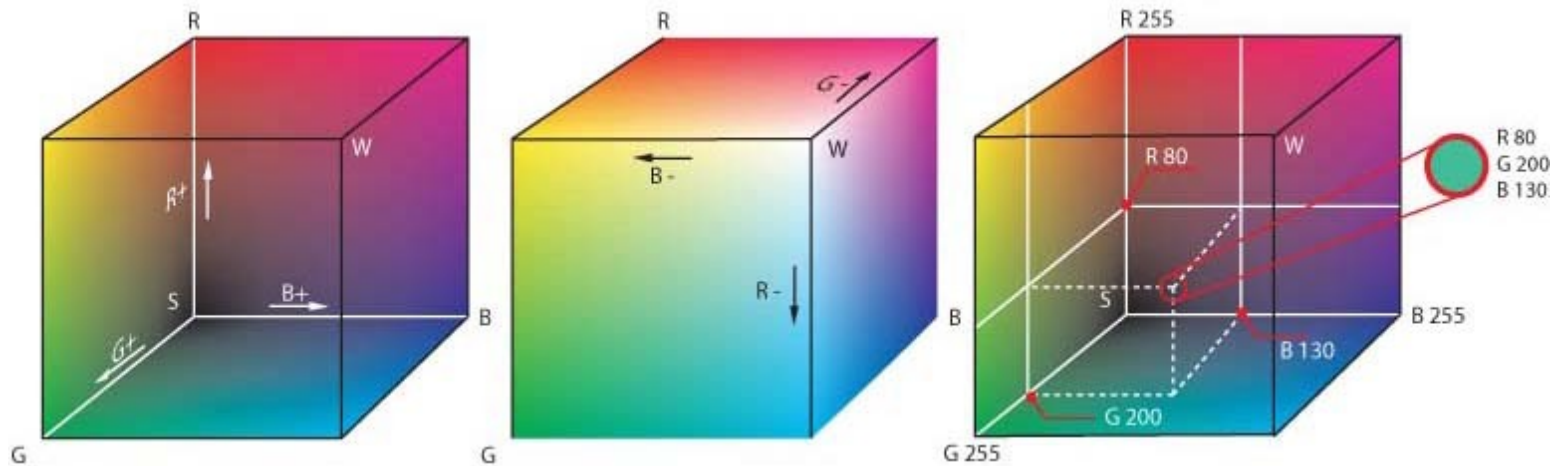
$$F_{RGB} = [F_R \mid F_G \mid F_B]$$



Combined Histogram

- Quantize multi-dimensional colour space.
- RGB
 - Each coefficient is a small 'cube' inside the RGB cube.

$$F = [f_0, \dots, f_N]$$

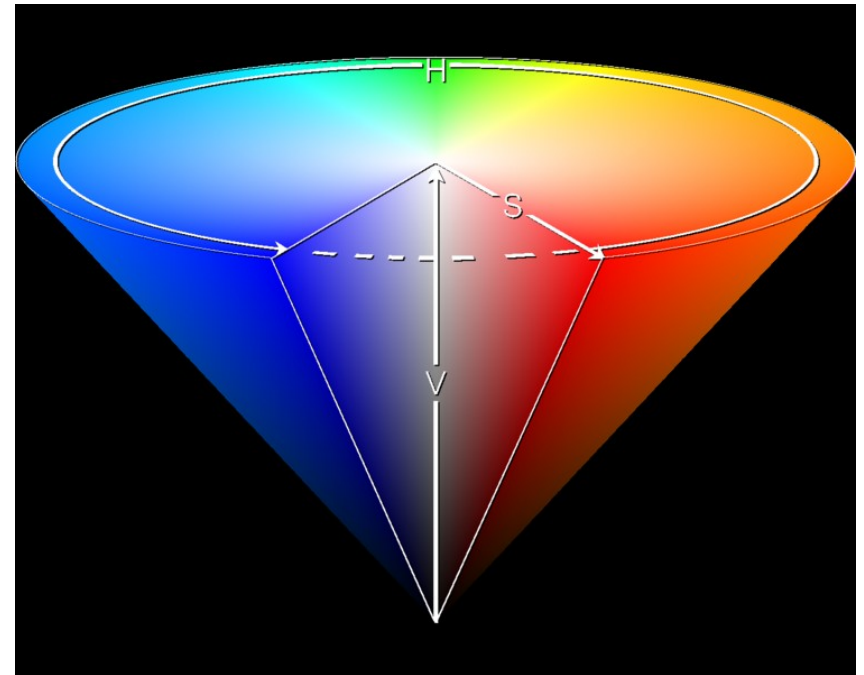


HSI Histogram

- Quantize HSI space.
 - Define number of bins N .
 - Feature vector

$$F_{HSI} = [f_0, \dots, f_N]$$

- Typically better for object description



MPEG-7 Dominant Colour

- Clusters colors into a small number of representative colors (salient colors)
- $\mathbf{F} = \{ \{ \mathbf{c}_i, \mathbf{p}_i, \mathbf{v}_i \}, \mathbf{s} \}$
 - \mathbf{c}_i : Representative colors
 - \mathbf{p}_i : Their percentages in the region
 - \mathbf{v}_i : Color variances
 - \mathbf{s} : Spatial coherency

MPEG-7 Scalable Colour

- HSI Histogram
- Typical quantization: 256 bins.
 - 16 levels in H
 - 4 levels in S
 - 4 levels in I
- Very popular for CBIR (Content-Based Image Retrieval).

$$F_{SC} = [f_0, \dots, f_{255}]$$

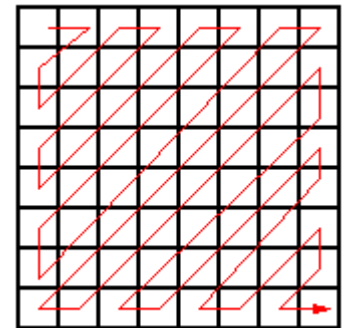


Fig. 2. Three color images and their MPEG-7 histogram color distribution, depicted using a simplified color histogram. Based on the color distribution, the two left images would be recognized as more similar compared to the one on the right.

[Sikora 2001]

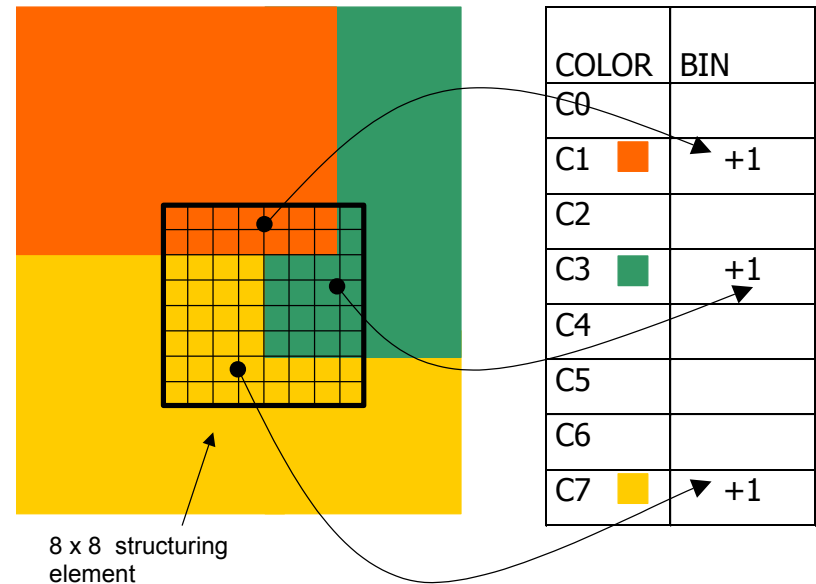
MPEG-7 Colour Layout

- Clusters the image into 64 (8x8) blocks
- Derives the average color of each block (or using DCD)
- Applies (8x8)DCT and encoding
- Efficient for
 - Sketch-based image retrieval
 - Content Filtering using image indexing



MPEG-7 Colour Structure

- Scans the image by an 8x8 struct. element
- Counts the number of blocks containing each color
- Generates a color histogram (HMMD/4CSQ operating points)



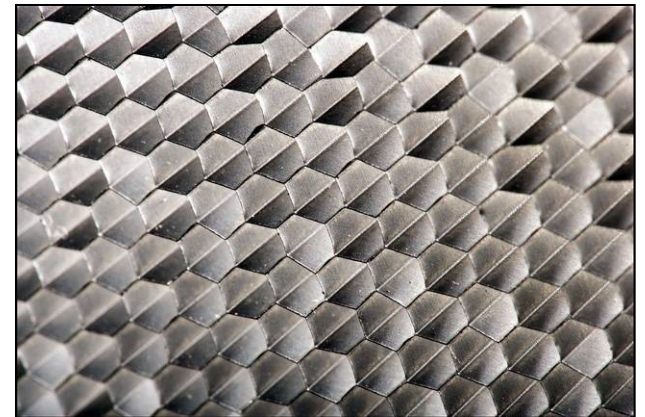
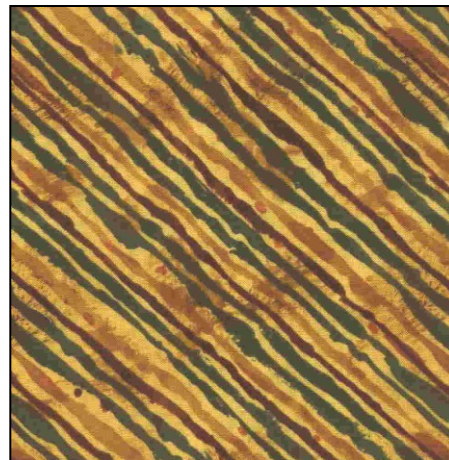
Topic: Texture

- Feature Vectors
- Colour
- **Texture**
- Shape

What is texture?

“Texture gives us information about the spatial arrangement of the colours or intensities in an image”.

[L. Shapiro]



Two approaches to texture

- **Structural approach**
 - Texture is a set of primitive *texels* in some regular or repeated relationship.
 - Good for regular, ‘man-made’ textures.
- **Statistical approach**
 - Texture is a quantitative measure of the arrangement of intensities in a region.
 - More general and easier to compute.

Statistical approaches

- Grey level of central pixels
- Average of grey levels in window
- Median
- Standard deviation of grey levels
- Difference of maximum and minimum grey levels
- Difference between average grey level in small and large windows
- Sobel feature
- Kirsch feature
- Derivative in x window
- Derivative in y window
- Diagonal derivatives
- Combine features



How do I pick one??

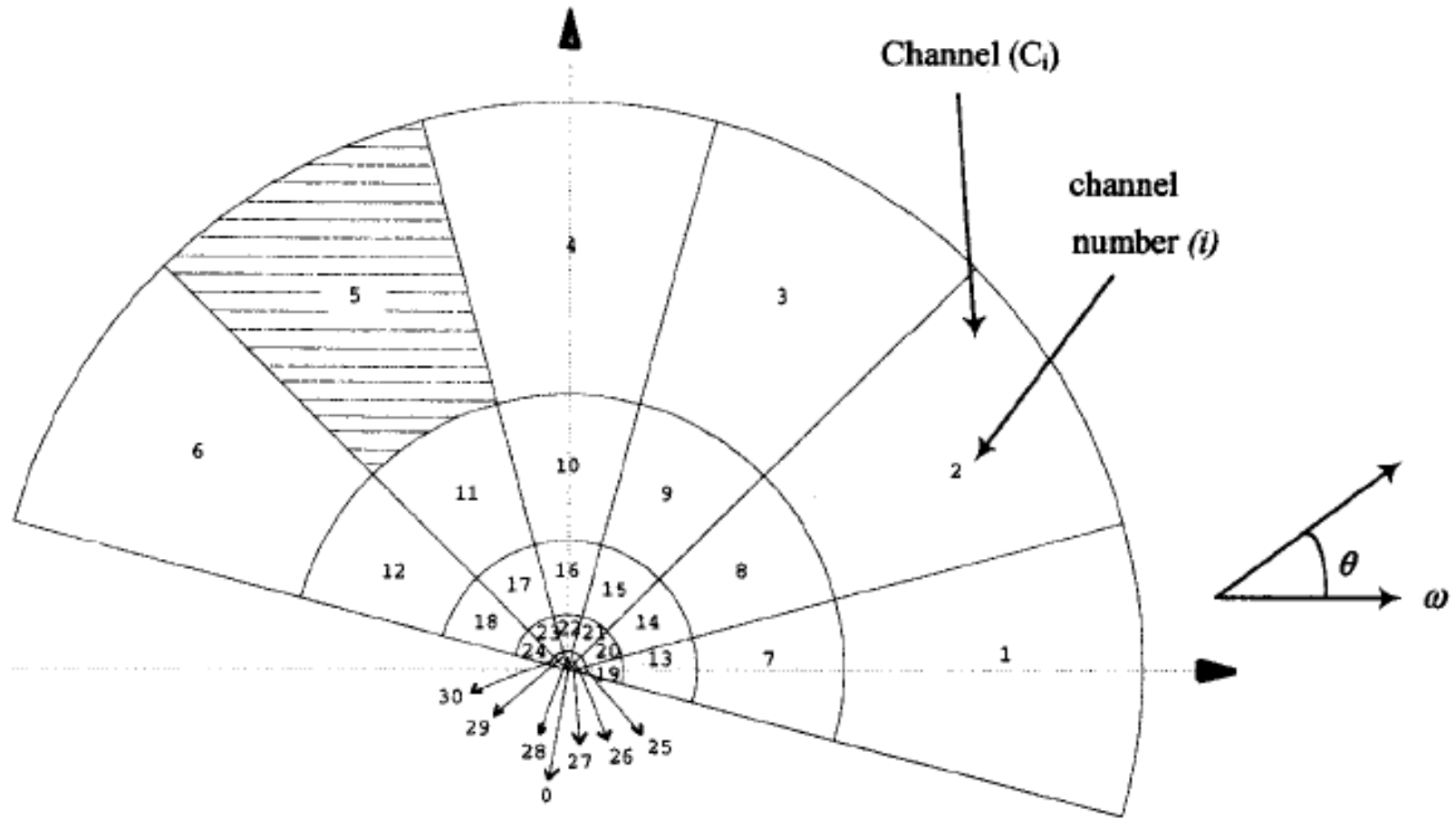
MPEG-7 Homogenous Texture

- Filters the image with a set of orientation and scale sensitive filters.
- Computes mean and standard deviation of response.
- 30 channels
 - 6 in angular direction, 5 in radial direction.

$$F_{HT} = [f_{DC}, f_{SC}, e_1, e_2, \dots, e_{30}, d_1, d_2, \dots, d_{30}]$$

*f*_{DC}, *f*_{SC} are the mean intensity and the standard deviation of image texture), where *e*_x and *d*_x are the logarithmically scaled texture energy and texture energy deviation coefficients.

HT Channels



MPEG-7 Local Edge Histogram

- Image divided into 4x4 sub-regions.
- Edge histogram computer for each sub-region.
- Five bins:
 - Vertical, horizontal, 45 diagonal, 135 diagonal, and isotropic.
- 80 total bins.

$$F_{LEH} = [f_0, \dots, f_{79}]$$

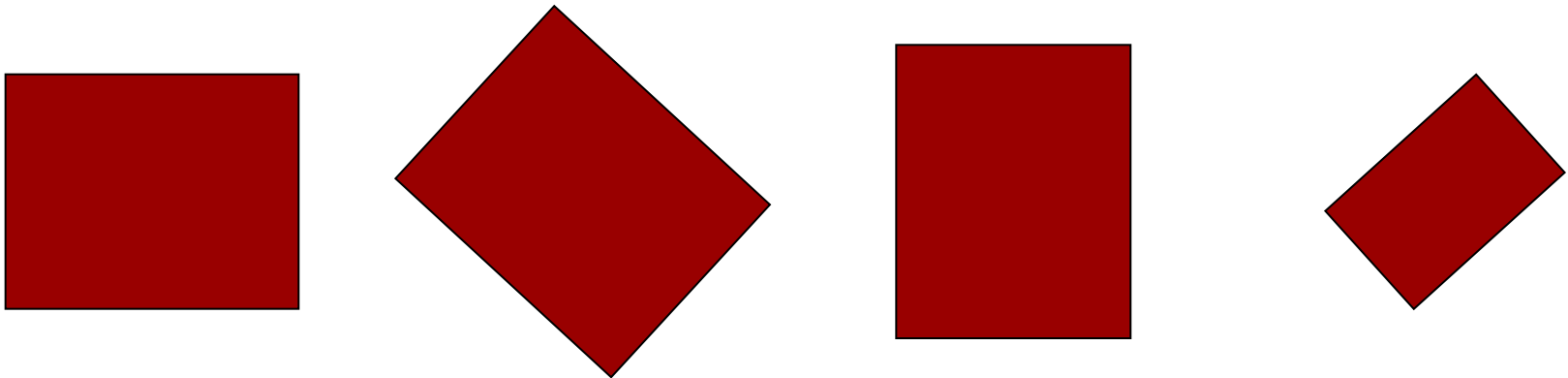
Topic: Shape

- Feature Vectors
- Colour
- Texture
- **Shape**

Definitions

- **Geometric definition**

Two sets have the same shape if one can be transformed into another by a combination of translations, rotations and uniform scaling operations.

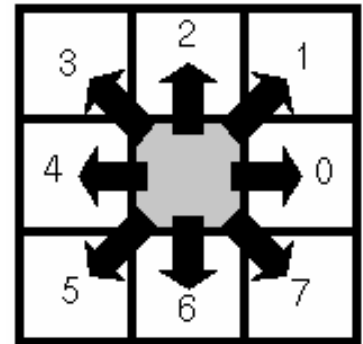
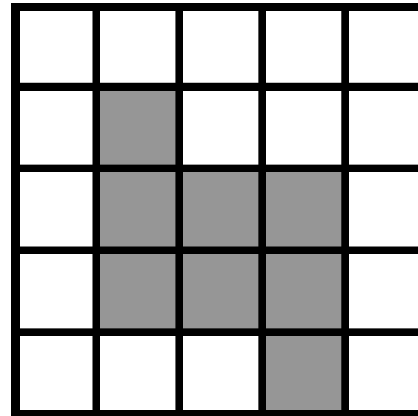


Shape and Segmentation

- **Shape implies a segmentation step.**
 - Segmentation has multiple solutions (middle-level feature).
 - But the shape feature itself has a single solution!
- **How do we describe shapes?**
 - Chain-codes
 - Statistical descriptors.

Freeman Chain Code

- Chains represent the borders of objects.
- Coding with *chain codes*.
 - Relative.
 - Assume an initial starting point for each object.
- How do we build a feature vector?



Freeman Chain Code

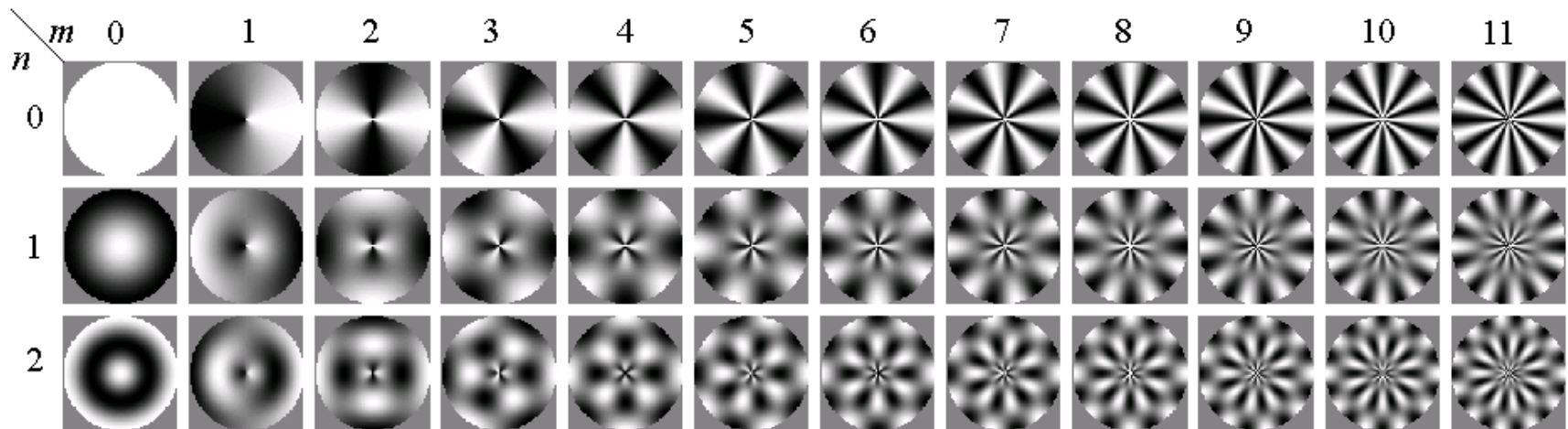
Using a Freeman Chain Code and considering the top-left pixel as the starting point:
70663422

MPEG-7 – Region-Based Shape

- Uses a set of separable ART (angular radial transformation) functions.
- Classifies shape along various angular and radial directions.
- Totals 35 coefficients.

$$F_{RBS} = [f_0, \dots, f_{34}]$$

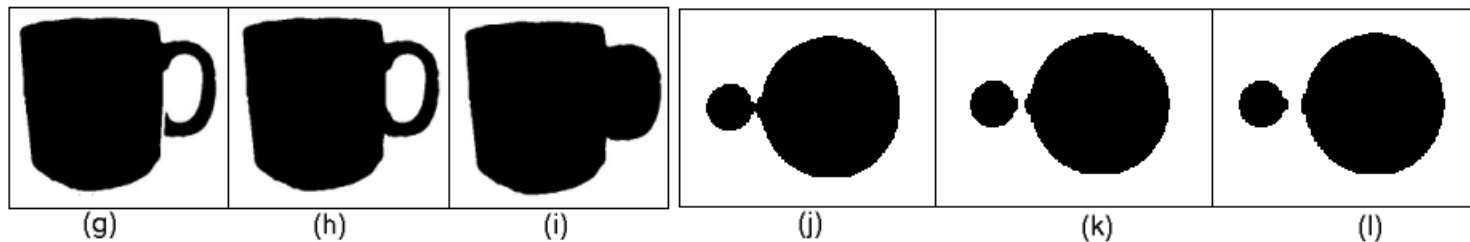
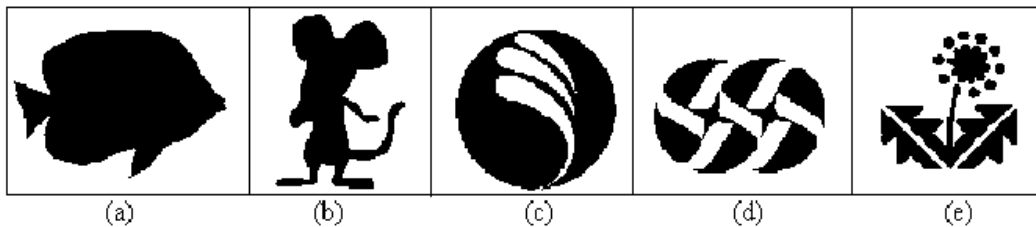
ART Basis Functions



- Applicable to figures (a) – (e)

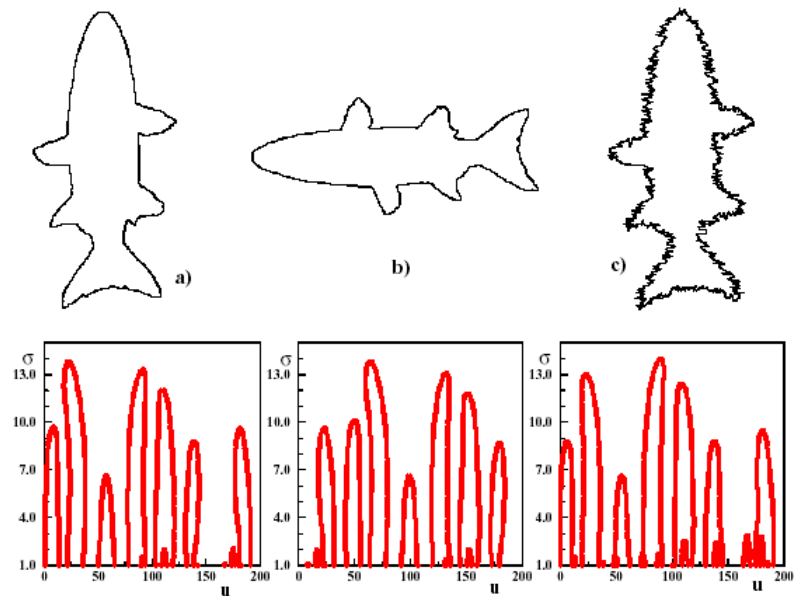
- Distinguishes (i) from (g) and (h)

- (j), (k), and (l) are similar



MPEG-7 – Contour-Based Descriptor

- Finds curvature zero crossing points of the shape's contour (key points)
- Reduces the number of key points step by step, by applying Gaussian smoothing
- The position of key points are expressed relative to the length of the contour curve



- Applicable to (a)
- Distinguishes differences in (b)
- Find similarities in (c) - (e)



(a)



(b)



(c)



(d)

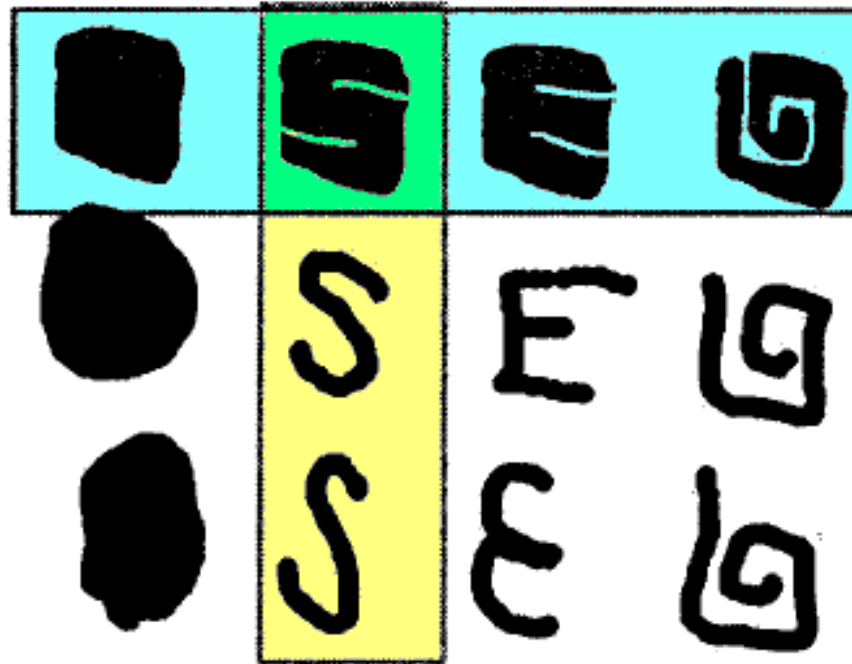


(e)

Advantages:

- Captures the shape very well
- Robust to the noise, scale, and orientation
- It is fast and compact

Comparison



- Blue: Similar shapes by Region-Based
- Yellow: Similar shapes by Contour-Based

Resources

- L. Shapiro, Chapters 6 and 7
- T. Sikora, “MPEG-7 Visual Standard for Content Description—An Overview”,
<http://ieeexplore.ieee.org/iel5/76/20050/00927422.pdf?arnumber=927422>