

# CAS CS 585

## Image and Video Computing

Lecture by Margrit Betke

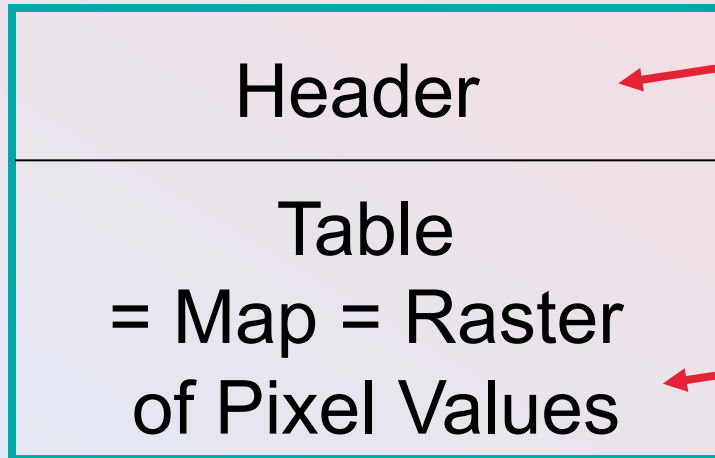
Topics: Image and Video Formats, Color, Projections, Multi-object Labeling (recursive & sequential), and Face Detection

# Digital Image File Formats



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Image:



Size of table, color,  
compression scheme

Gray-scale images: generally  
1 byte per pixel

Medical images: typically  
2 bytes per pixel

Color images: 3 numbers  
(each 1 byte) per pixel

# Example: PGM Image



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Image file

Image ??

P2
3 3 255
0 255 0
220 0 20
0 130 0

# Example: PGM Image

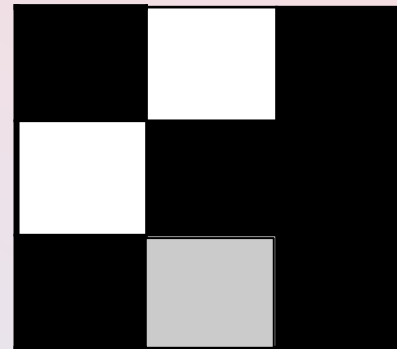


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Image file

Image

P2
3 3 255
0 255 0
220 0 20
0 130 0



# Light: Electromagnetic Waves



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Wavelength  $\lambda$

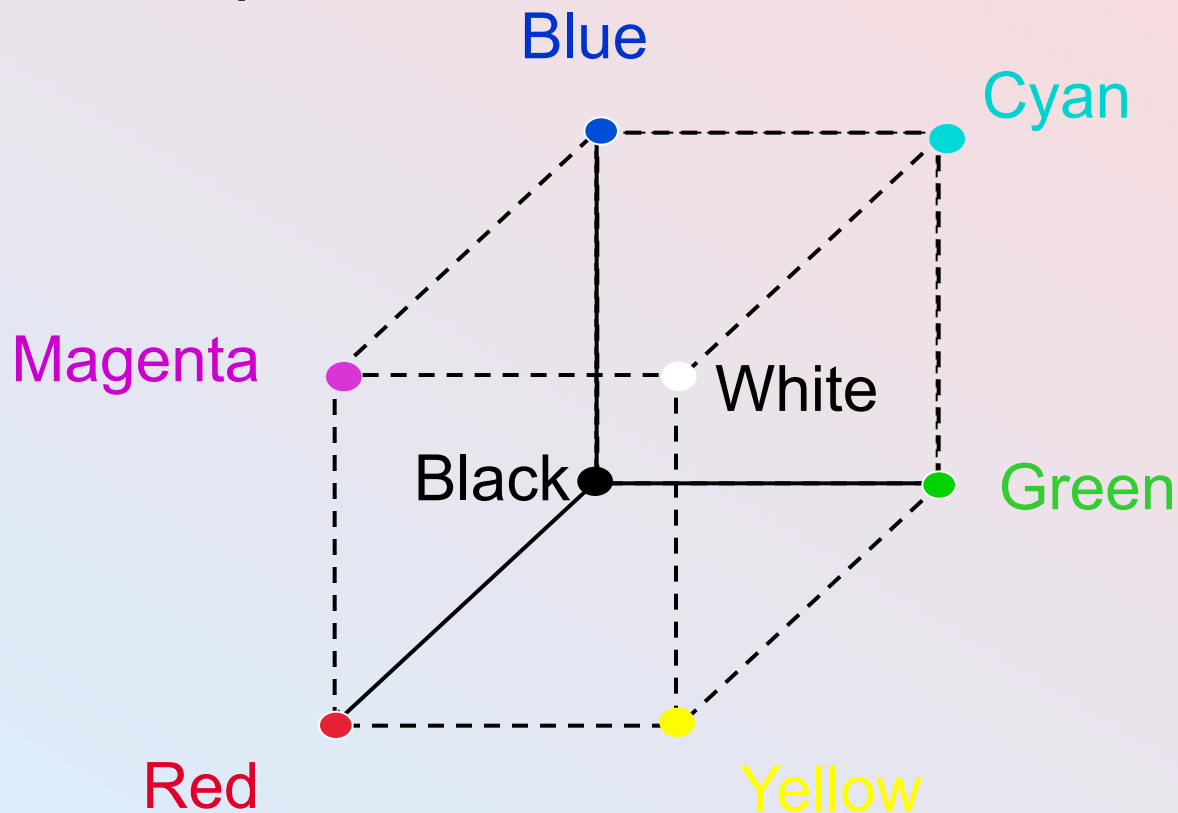


# RGB Color Space



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## Additive Space



# Example: PPM Image



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Image file

P3

3 3 255

0	0	0	255	0	0	0	0	0
0	255	0	0	0	0	255	255	0
0	0	0	0	0	255	0	0	0

Image ??

# Example: PPM Image



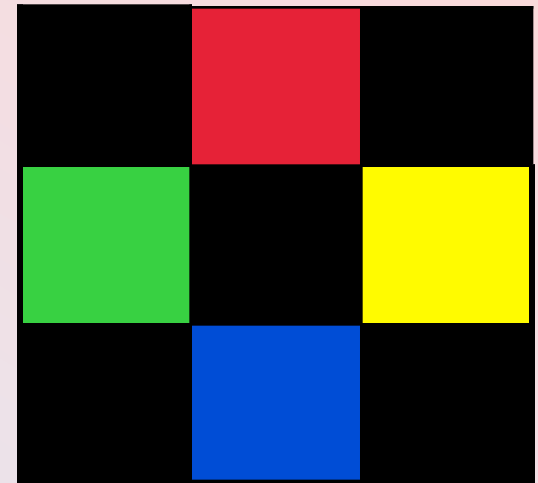
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## Image file

```
P3  
3 3 255
```

```
0 0 0 255 0 0 0 0 0  
0 255 0 0 0 0 255 255 0  
0 0 0 0 0 255 0 0 0
```

## Image





# Hue-Saturation-Value (HSV) Color Space

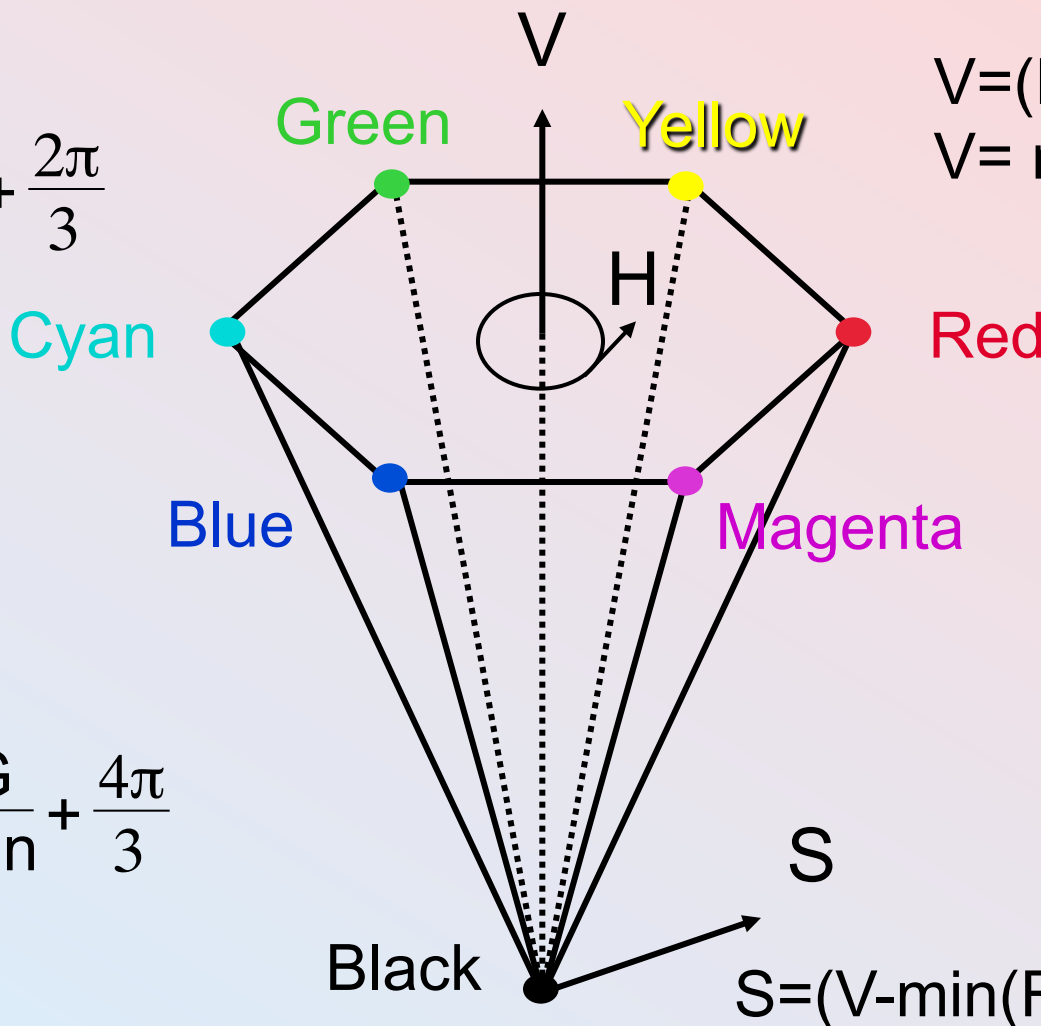


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near G:

$$H = \frac{\pi}{3} \frac{B-R}{V-\min} + \frac{2\pi}{3}$$

$$V = (R+B+G)/3 \text{ or } V = \max(R,G,B)$$



near R:

$$H = \frac{\pi}{3} \frac{G-B}{V-\min}$$

near B:

$$H = \frac{\pi}{3} \frac{R-G}{V-\min} + \frac{4\pi}{3}$$

$$S = (V - \min(R,G,B)) / V$$

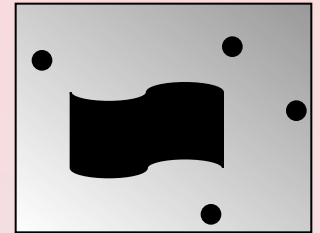
# Object Detection



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1. Find bounding box around black object in grayscale background

Background may contain black pixels



Algorithm ??

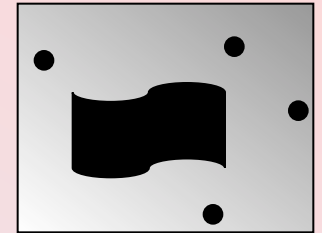
# Using Black Color & Projections for Object Detection



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## 1. Find bounding box around black object in grayscale background

Background may contain black pixels



### Algorithm:

- Count number of black pixels in each row and column
- Analyze these histograms or projections of black pixels onto x- and y-axes.

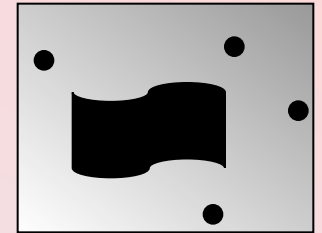
# Using Black Color & Projections for Object Detection



Computer Science

## 1. Find bounding box around black object in grayscale background

Background may contain black pixels



### Algorithm:

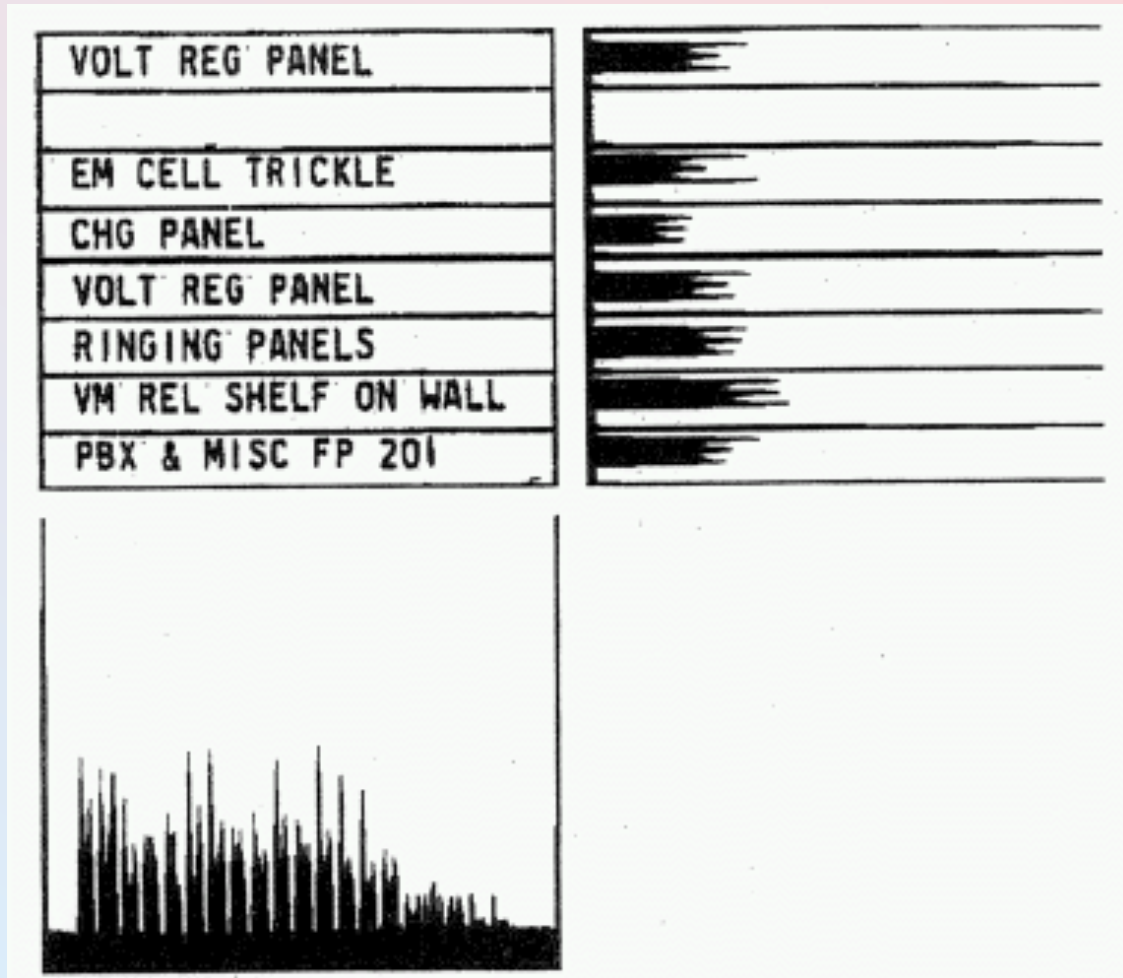
- Count number of black pixels in each row and column
- Analyze these histograms or projections of black pixels onto x- and y-axes.

$$P1(y) = \sum_x B(x,y), \quad P2(x) = \sum_y B(x,y)$$

# Examples of Projections



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# Examples of Projections



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String Quintet in B-flat Major, K.174

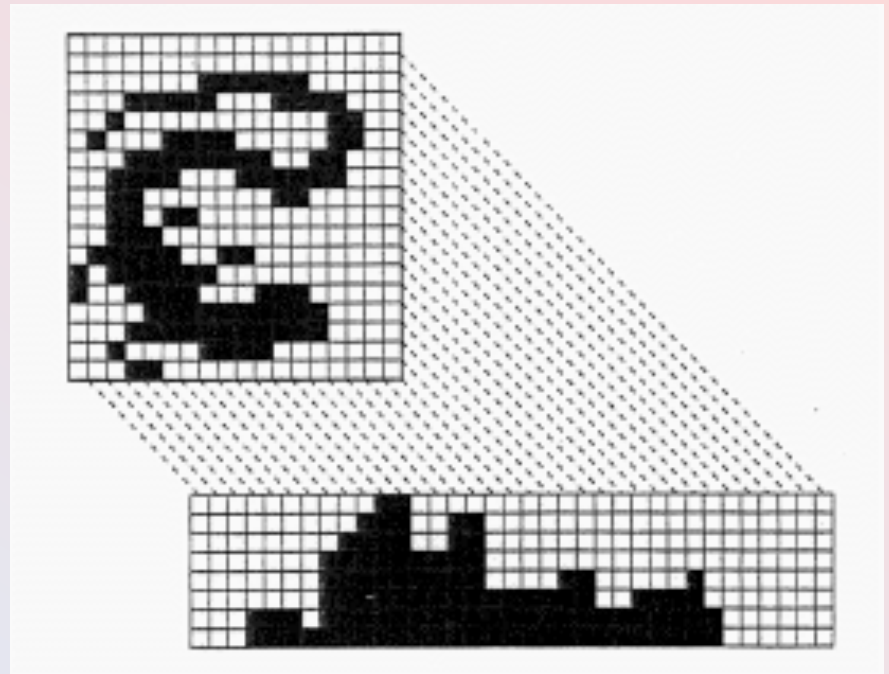
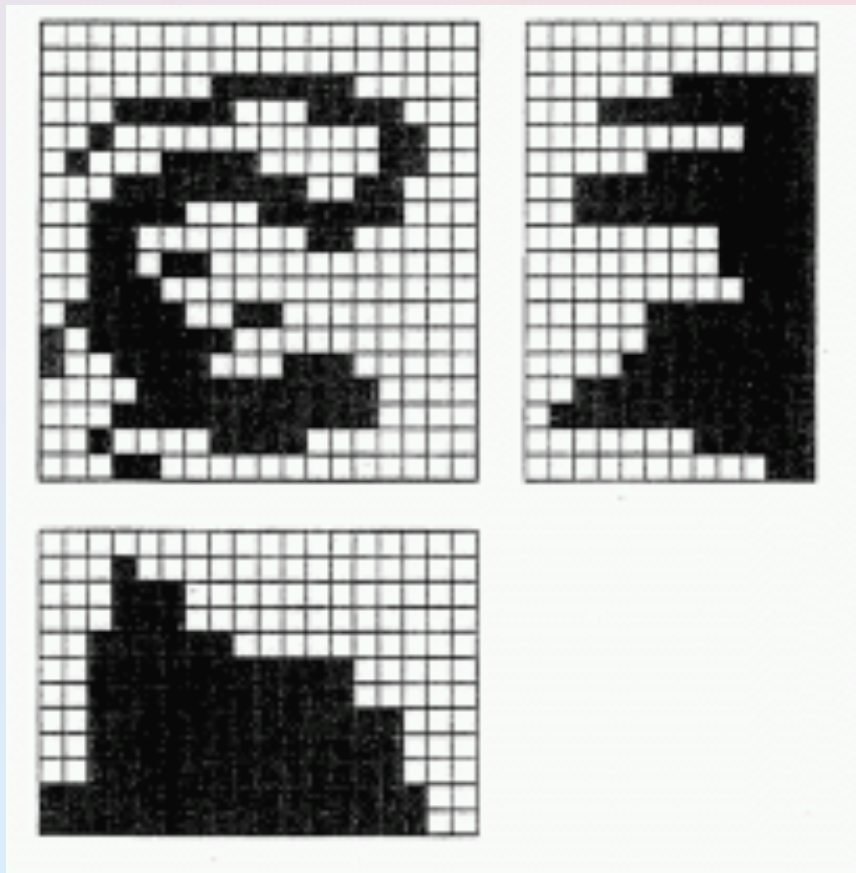
*Allegro moderato.*

The image displays a musical score for a String Quintet in B-flat Major, K.174, by Wolfgang Amadeus Mozart. The score is arranged in five staves, labeled Violino I, Violino II, Viola I, Viola II, and Basso (Violoncello). The tempo is marked 'Allegro moderato.' To the right of the score, a vertical projection visualization is shown, with the word 'projection' written above it. This visualization consists of a series of horizontal black bars of varying lengths, representing the amplitude or energy of the music over time. The bars are aligned with the musical staves, showing the relative intensity of each instrument's contribution to the overall sound.

# Examples of Projections



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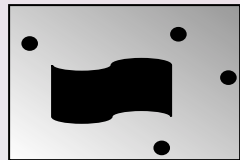
From Machine Vision by  
Jain et al.

# Object Detection: Alternative Algorithm: “Flood Fill”

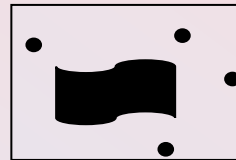


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## 1. Convert to binary image:



-->



Black = “-1” pixels

White = “1” pixels

2. Scan row by row until first “-1” pixel is reached and label it “object 1.”
3. Find all neighbors of the current pixel that are “-1” and assign the object label of the current object in a recursive, depth first search manner.
4. When there are no more “-1” neighbors, continue scanning the image until the next “-1” pixel is reached and label it with the next object label and go to step 3.



# Sequential Multi-Object Labeling Algorithm



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- ❑ Horn, page 69
- ❑ More explanation with an example next time

D	C
B	A

# Sequential Labeling Algorithm



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Case 1:

D labeled  
B, C not

L	C
B	A

L	C
B	L

Case 2:

Either  
B or C  
labeled

D	L
B	A

D	L
B	L

D	C
L	A

D	C
L	L

Case 3:

Neither  
B, C, or D  
labeled

D	C
B	A

D	C
B	L

Case 4:

B, C  
labeled  
same different

D	L
L	A

D	L
L	L

D	L
L	A

D	L
L	L

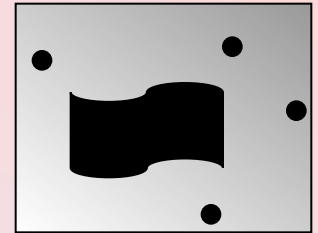
# Back to Algorithm that uses Black Color & Projections for Object Detection



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## 1. Find bounding box around black object in grayscale background

Background may contain black pixels



### Algorithm:

- Count number of black pixels in each row and column
- Analyze these histograms or projections of black pixels onto x- and y-axes.

$$P1(y) = \sum_x B(x,y), \quad P2(x) = \sum_y B(x,y)$$

# Using Skin Color for Face Detection



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2. Find bounding box around face in color image

Algorithm ??



# Using Skin Color for Face Detection



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## 2. Find bounding box around face in color image

### Algorithm: Same Idea

- Find all pixels with skin color
- Count number of skin color pixels in each row and column
- Analyze these histograms or projections of skin-color pixels onto x- and y-axes.

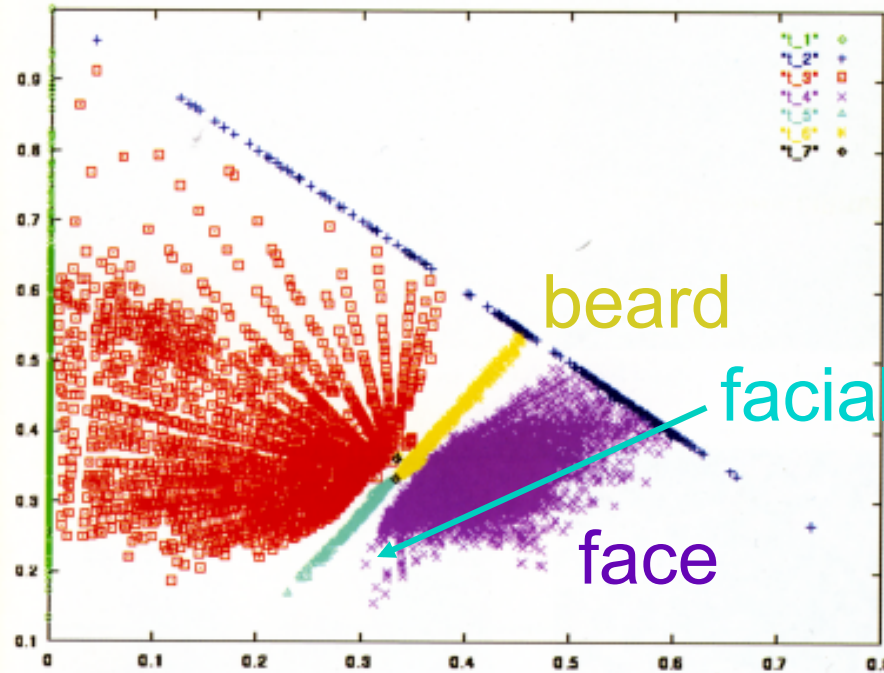


Normalized  
Green



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# Using skin color for face detection



Normalized  
Red

▲ Figure 6.12

Skin color clusters obtained from training: the horizontal axis is  $R_{norm}$  and the vertical axis is  $G_{norm}$ . The cluster labeled as  $t_4$  is the primary face color, cluster  $t_5$  and  $t_6$  are secondary face clusters associated with shadowed or bearded areas of a face. (Figure from V. Bakic.)

▼ Figure 6.13

Face extraction examples: (left) input image; (middle) labeled image; and (right) boundaries of the extracted face region. (Images from V. Bakic.)



From Computer Vision by  
Shapiro & Stockman