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

Computer Science

Image:

Header
Table = Map = Raster of Pixel Values

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

Computer Science

Image file

Image ??

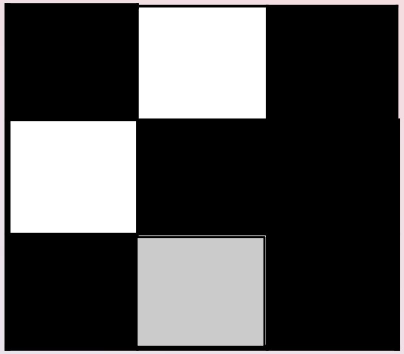
```
P2
3   3   255
-------------
0   255   0
220   0   20
0   130   0
```

Example: PGM Image

Image file

```
P2
3   3   255
-----------------
0    255   0
220   0   20
0    130   0
```

Image



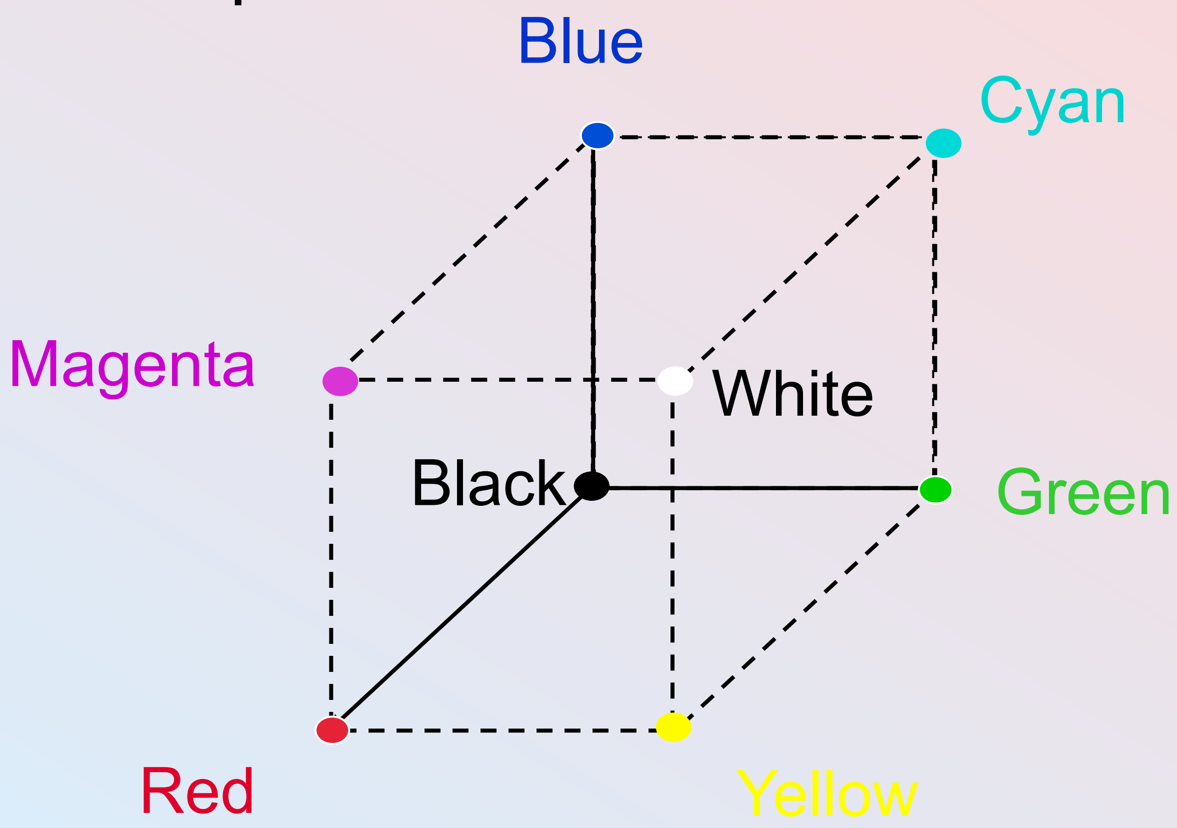
Light: Electromagnetic Waves

Computer Science

Wavelength λ

RGB Color Space

Additive Space



Example: PPM Image

Computer Science

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 ??

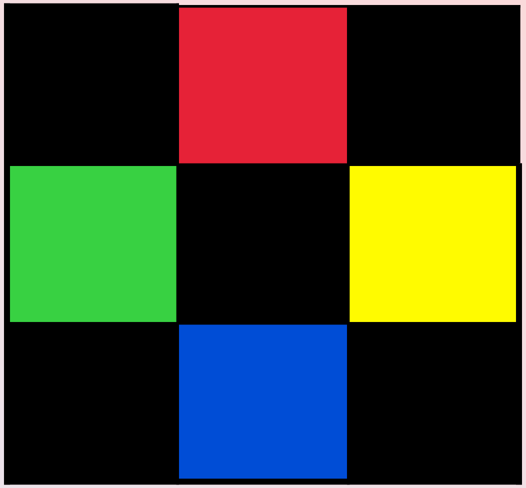
Example: PPM Image

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
```

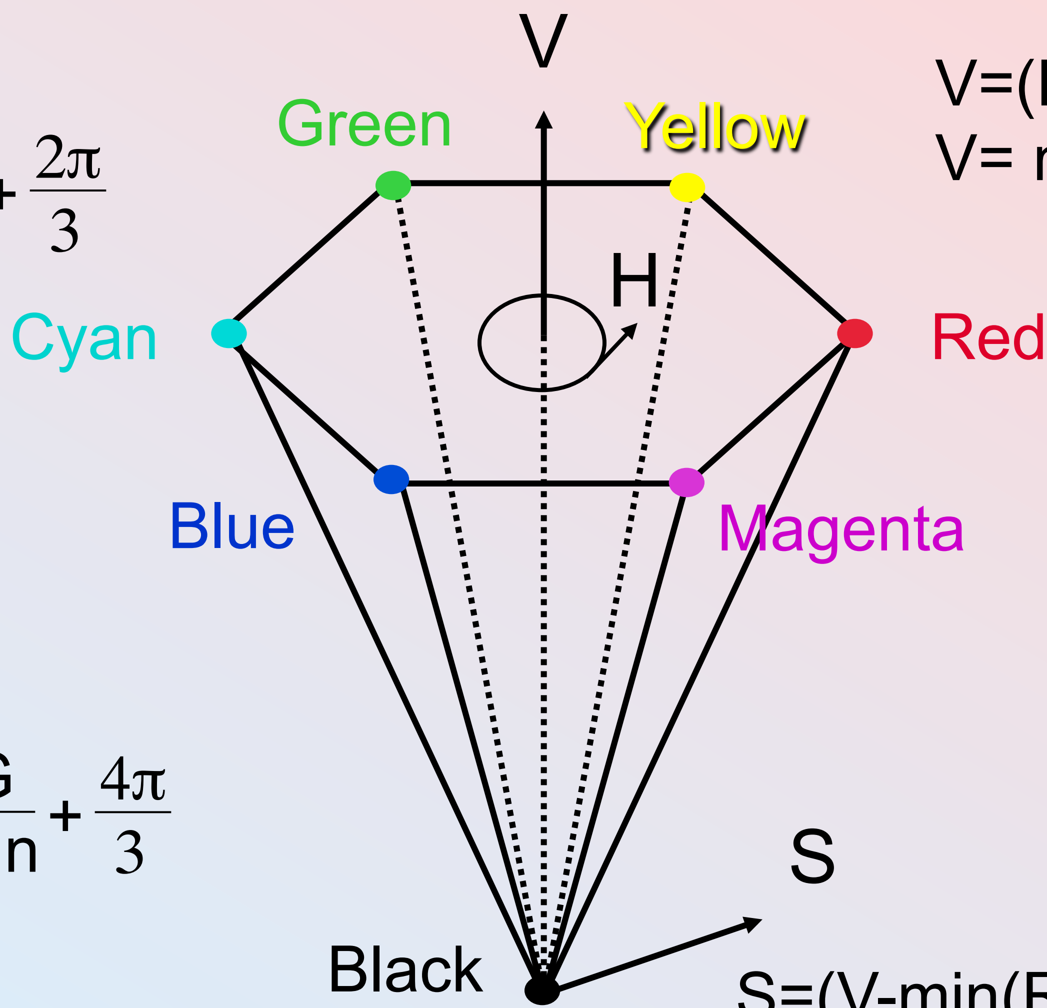
Image



Hue-Saturation-Value (HSV) Color Space

near G:

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



V=(R+B+G)/3 or
V= max(R,G,B)

near R:

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

near B:

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

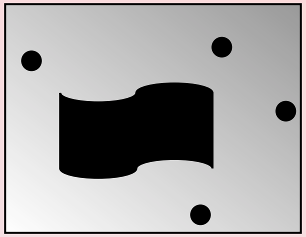
S=(V-min(R,G,B))/V

Object Detection

Computer Science

1. Find bounding box around black object in grayscale background

    Background may contain black pixels



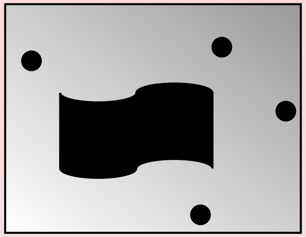
Algorithm ??

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:

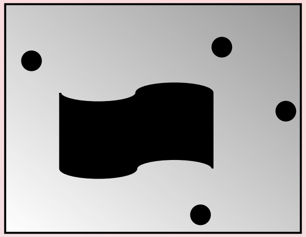
- Count number of black pixels in each row and column
- Analyze these histograms or projections of black pixels onto x- and y-axes.

Using Black Color & Projections for Object Detection

Computer Science

1. Find bounding box around black object in grayscale background

Background may contain black pixels

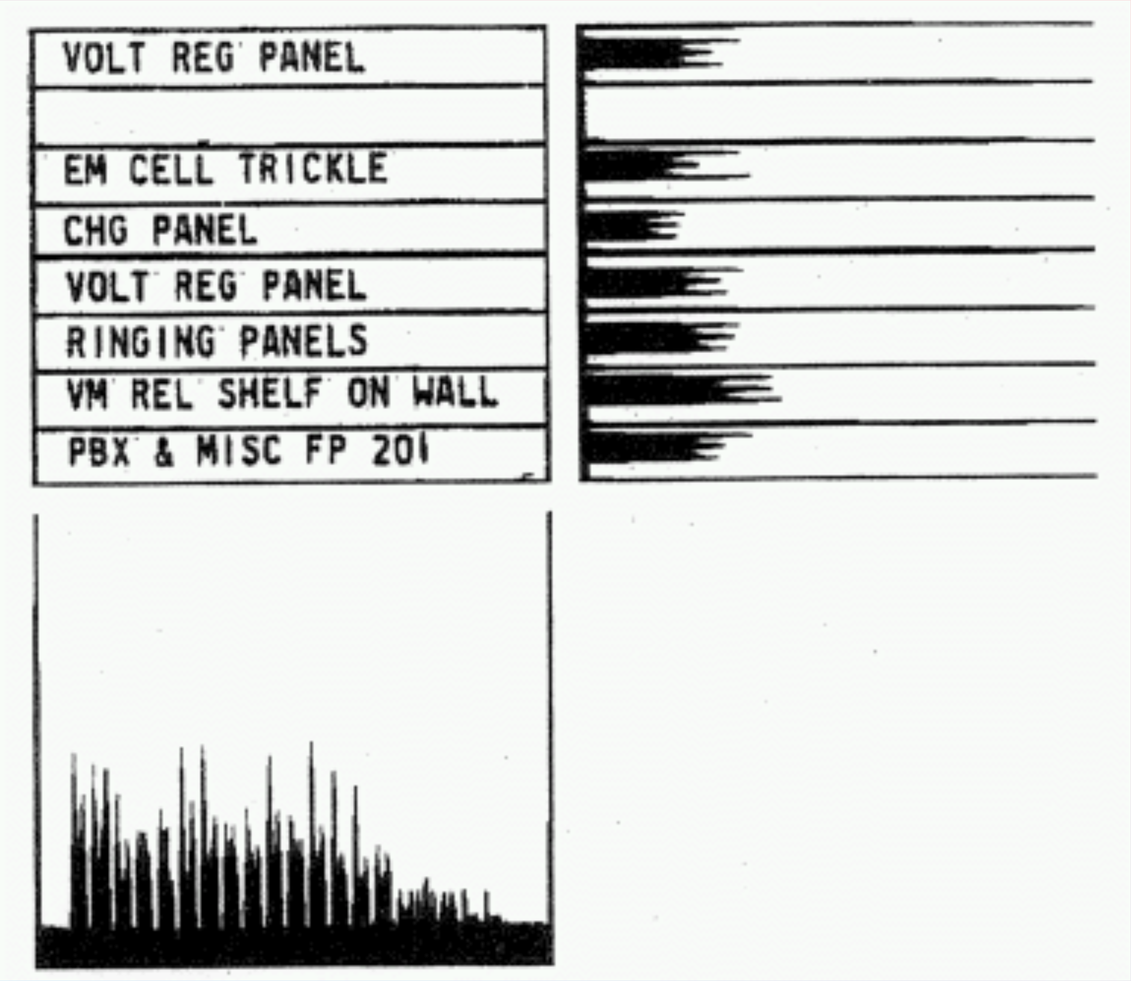


Algorithm:

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

$$P1(y)= \Sigma_x B(x,y), \quad P2(x)= \Sigma_y B(x,y)$$

Examples of Projections

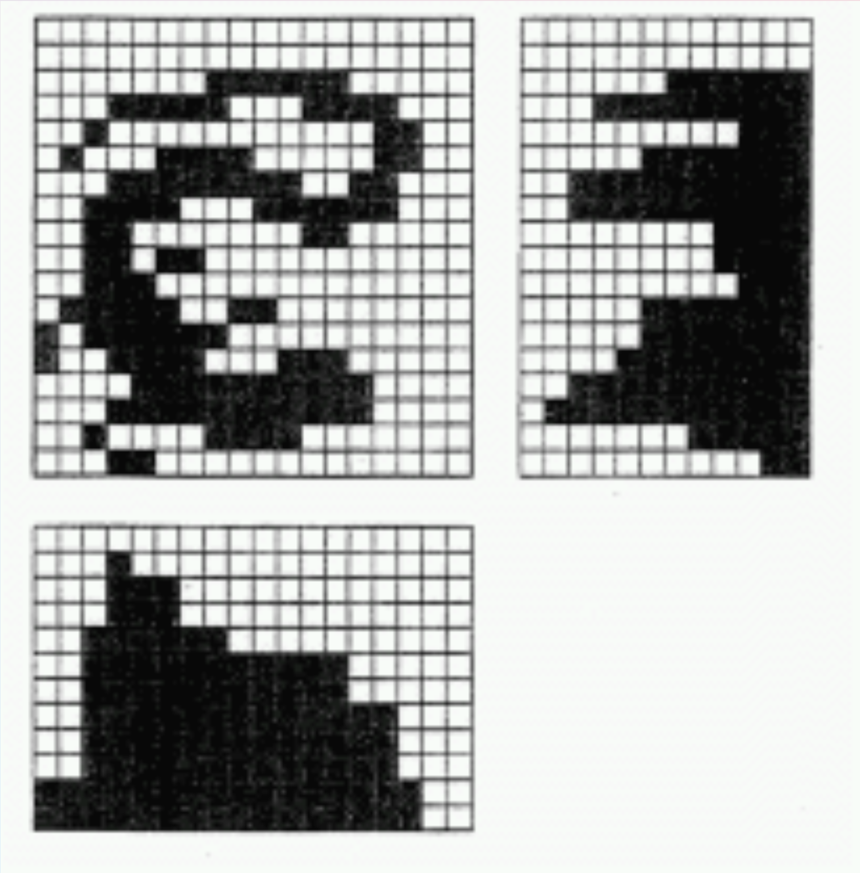


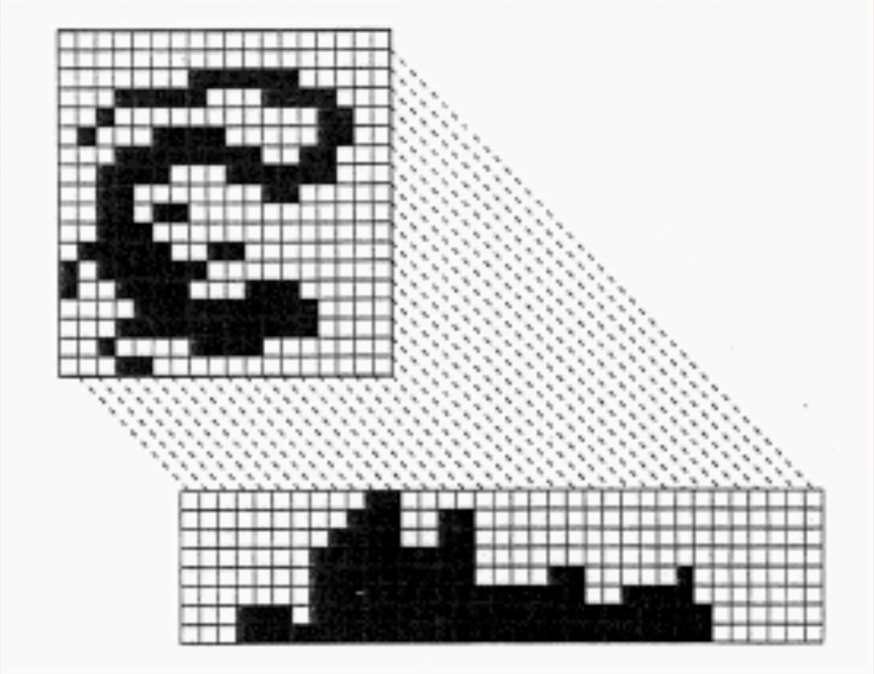
Examples of Projections

Computer Science

Examples of Projections

Computer Science

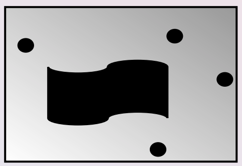




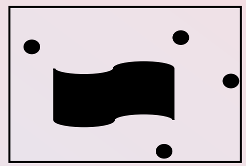
From Machine Vision by
Jain et al.

Object Detection: Alternative Algorithm: "Flood Fill"

1. Convert to binary image:



-->



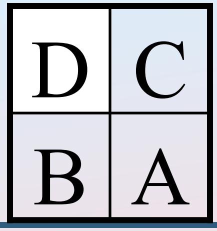
Black = "-1" pixels

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

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



Sequential Labeling Algorithm

Computer Science

Case 1:

D labeled
B, C not

Case 2:

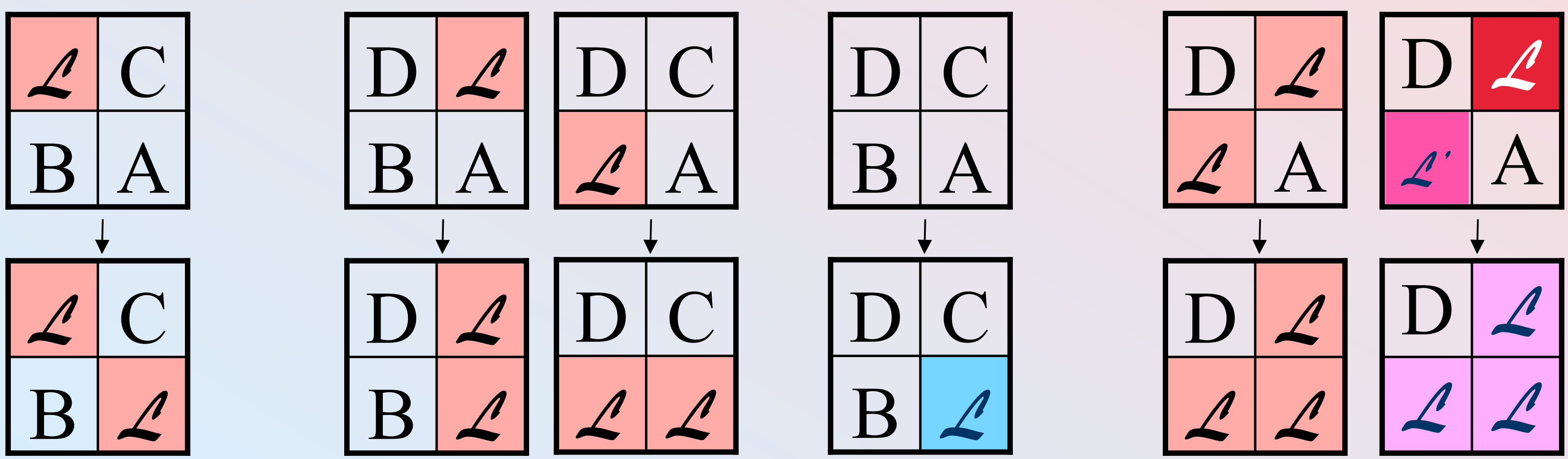
Either
B or C
labeled

Case 3:

Neither
B,C, or D
labeled

Case 4:

B, C
labeled
same   different

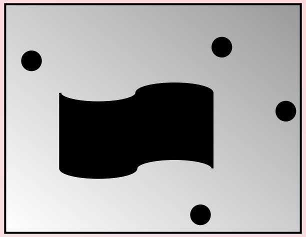


Back to Algorithm that uses Black Color & Projections for Object Detection

Computer Science

1. Find bounding box around black object in grayscale background

Background may contain black pixels



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Using Skin Color for Face Detection

2. Find bounding box around face in color image

   Algorithm ??

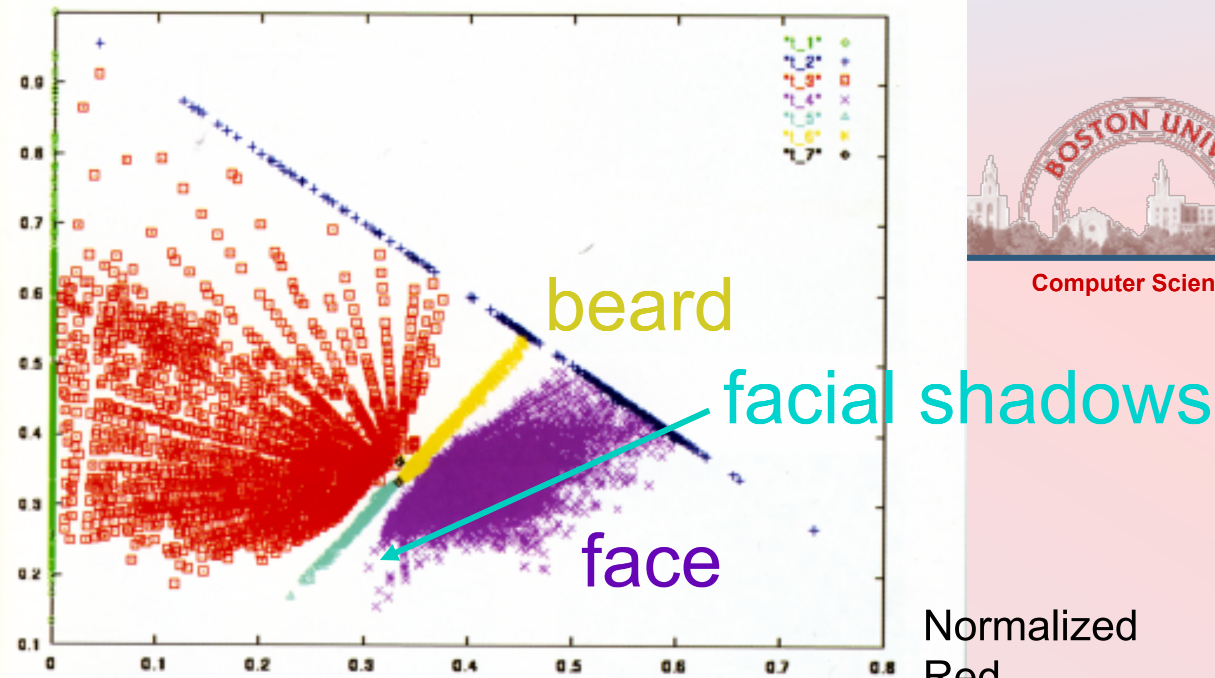
Using Skin Color for Face Detection

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.

Using skin color for face detection



▲ **Figure 6.12**
Skin color clusters obtained from training: the horizontal axis is Rnorm 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