# Image & Color







Binary Image

Grayscale Image

Color Image

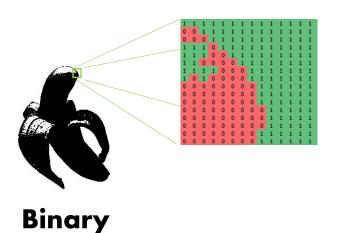
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4 136 150 138 122 115 104 113 105 95 146 236 249
3 105 116 137 143 122 114 116 108 98 79 129 191
0 89 94 110 128 140 119 111 116 103 103 87 101
5 105 99 95 95 118 131 115 107 116 119 109 106
8 95 105 111 95 104 125 121 107 107 113 117 120
2 119 96 109 91 90 111 124 119 112 111 123 127
5 123 125 114 110 98 95 111 125 122 115 126 132
4 142 132 136 139 116 89 93 113 121 121 131 132
0 151 148 142 140 121 100 95 102 115 131 132 128
1 129 184 159 144 129 123 114 104 116 143 134 135



Grayscale Image

8-bit => 0-255

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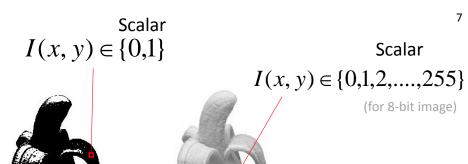
**Image** 

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#### Blue Green 133 131 133 138 146 155 162 155 157 146 142 Red 136 141 150 157 161 154 148 147 152 146 147 137 139 142 150 156 154 148 154 173 184 194 202 202 198 192 188 183 189 201 154 153 147 175 170 171 179 186 192 195 185 180 181 1877 151 155 149 171 168 170 175 180 189 195 186 191 184 181 174 180 187 194 195 189 181 178 186 184 1873 157 154 Color 175 177 180 187 193 189 181 187 193 187 1845 148 154 153 175 172 174 179 183 179 177 186 186 191 1842 151 154 153 188 181 179 183 187 187 190 179 183 191 1854 154 149 147 182 179 178 184 186 186 193 189 190 192 1813 158 152 150 **Image** 197 192 185 183 178 174 180 183 188 192 182 182 181 179 183 187 193 203 186 189 190 179 179 101 100 177 179 103 107 191 190 109 179 179 186 187 178 177 181 174 179 181 189 185 174 181 185 177 182 192 183 184 183 188 185

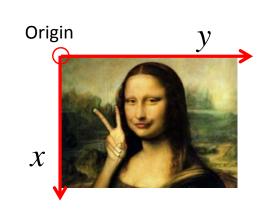
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Binary Image Grayscale Image

## Image = 2-D Function



I(x, y)

**Pixel Coordinates** 

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Vector ┌╭┐

$$I(x, y) = \begin{bmatrix} r \\ g \\ b \end{bmatrix}$$

 $r, g, b \in \{0,1,2,\dots,255\}$ 

(for 8-bit image)

r,g,b = Color components (Red, Green, Blue Components) Color Image



- [255 255 255]
- $[0 \ 0 \ 0]$

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- [0 255 255]  $\bigcirc$
- (B) [255 0 255]
- [255 255 0]

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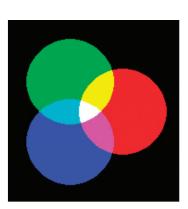
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**RGB** Color Space



- $\bigcirc$ [150 0 0]
- $\bigcirc$ B [255 0 0]
- (C) [255 150 150]



I(x,y) = gBlue light

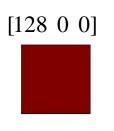
**Mixture of Lights** 

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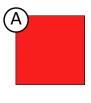
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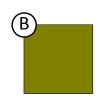
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#### Which one is more similar?





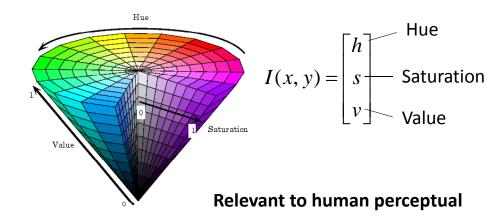
[250 30 30]

[128 128 0]

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## **HSV Color Space**



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## $RGB \Rightarrow HSV$

cyan(180°) 
$$\rightarrow$$
 red(0°)  $\rightarrow$  blue(240°) mageta(300°)

$$M = \max(r, g, b)$$

$$m = \min(r, g, b)$$

$$V = M$$

$$s = 1 - \frac{m}{M}$$

$$\frac{g - b}{M - m} \times 60^{\circ} \mod 360^{\circ}; M = r$$

$$\frac{b - r}{M - m} \times 60^{\circ} + 120^{\circ}; M = g$$

$$\frac{r - g}{M - m} \times 60^{\circ} + 240^{\circ}; M = b$$

$$r, g, b \in [0, 255]$$

$$h \in [0^{\circ}, 360^{\circ}]$$

$$s \in [0, 1]$$

$$v \in [0, 255]$$

#### $RGB \Rightarrow HSV$



$$[rgb] = [128\ 0\ 0]$$

$$M = \max(r, g, b) = 128$$
$$m = \min(r, g, b) = 0$$

$$h = \frac{g - b}{M - m} \times 60^\circ = 0$$

$$v = M = 128$$

$$s = 1 - \frac{m}{M} = 1$$

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#### 1

### $RGB \Rightarrow HSV$



$$[rgb] = [250 \ 30 \ 30]$$

$$M = \max(r, g, b) = 250$$
$$m = \min(r, g, b) = 30$$

$$h = \frac{g - b}{M - m} \times 60^{\circ} = 0$$

$$v = M = 250$$

$$s = 1 - \frac{m}{M} = 0.88$$

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### $RGB \Rightarrow HSV$



$$[rgb] = [128 \ 128 \ 0]$$

$$M = \max(r, g, b) = 128$$
$$m = \min(r, g, b) = 0$$

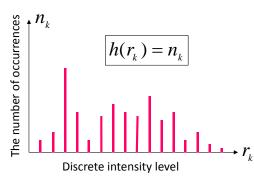
$$h = \frac{g - b}{M - m} \times 60^{\circ} = 60^{\circ}$$

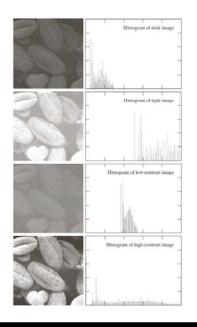
$$v = M = 128$$

$$s = 1 - \frac{m}{M} = 1$$

## Histogram

• Representation of the number of occurrences  $(n_k)$  of each possible intensity level  $(r_k)$  in the entire image



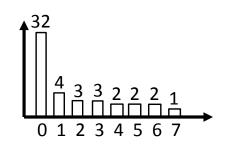


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## Histogram

0	0	0	2	1	0	0
0	0	0	0	1	1	0
0	0	0	0	0	2	0
0	1	0	0	0	3	4
4	3	0	0	0	3	6
5	5	0	0	0	2	0
0	6	7	0	0	0	0



## Histogram for Color Image



**Intensity Histograms** 

$$i = \frac{1}{3}(r+g+b)$$











**Individual Color Channel Histograms** 

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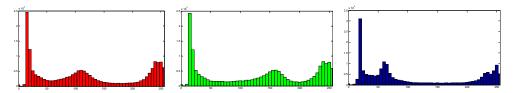
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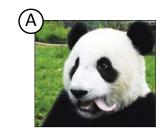
#1

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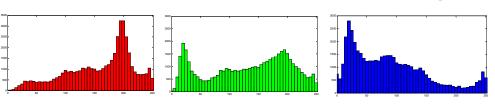
## Histogram for Color Image



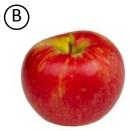


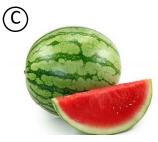


## Histogram for Color Image

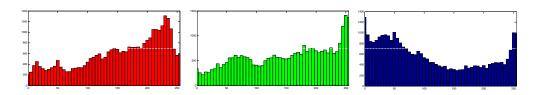








## Histogram for Color Image











(C)



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#### **White Chocolate Counting**



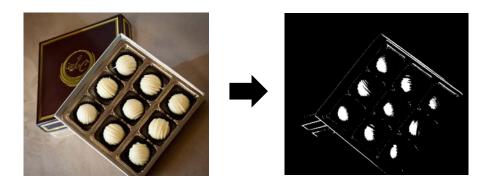




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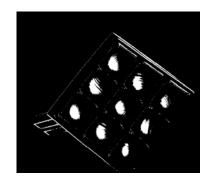
#1

## **Color Thresholding**

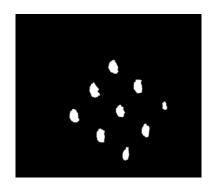


r > 230, g > 200, b > 150

## **Morphological Operators**







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#### **Connected Component Labeling**

[Blob Detection]

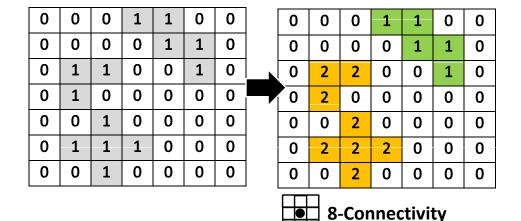
4-Connectivity

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### **Connected Component Labeling**

[Blob Detection]

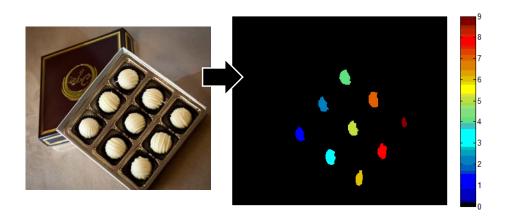


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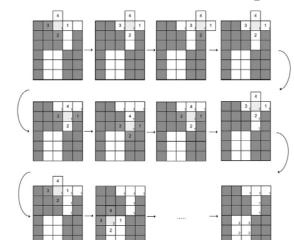
#1

#### **Connected Component Labeling**

[Blob Detection]



**Connected Component Labeling** 



http://what-when-how.com/introduction-to-video-and-imageprocessing/blob-analysis-introduction-to-video-and-image-processing-part-1/ [Blob Detection]

#### Two-pass algorithm

- Scan pixel by column, then by row
- If the pixel ≠ background, find the neighbor with the smallest label, assign it to the pixel and Store the equivalence between neighboring labels
- If there are no labeled neighbors, assign the pixel with new label
- Scan image again aand relabel the element with the lowest equivalent label

0	0	0	0	0	0	0	
0	0	0	1	0	0	0	
0	0	0	1	0	0	0	
0	0	0	1	0	0	0	
0	0	0	0	0	0	0	
0	1	1	0	1	1	0	
0	1	1	0	1	1	0	

**Equivalent List** 

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### **Connected Component Labeling**

[Blob Detection]

0	0	0	1	1	0	0
0	1	1	1	1	1	0
0	0	0	0	0	1	0
0	0	1	1	0	1	0
0	0	0	0	0	1	0
0	1	1	1	1	1	0
0	0	0	1	1	0	0

**Equivalent List** 1-2, 1-4

1<sup>st</sup> pass (8 connectivity)

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### **Connected Component Labeling**

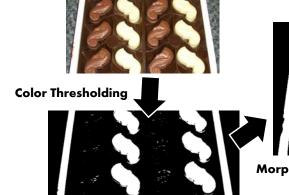
[Blob Detection]

0	0	0	1	1	0	0	
0	1	1	1	1	1	0	
0	0	0	0	0	1	0	
0	0	1	1	0	1	0	
0	0	0	0	0	1	0	
0	1	1	1	1	1	0	
0	0	0	1	1	0	0	

**Equivalent List** 1-2, 1-4

2<sup>nd</sup> pass (8 connectivity)

## White Chocolate Counting



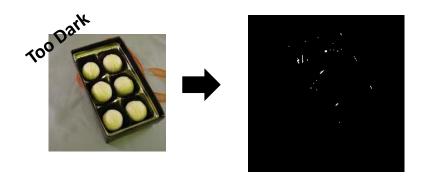


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## **White Chocolate Counting**

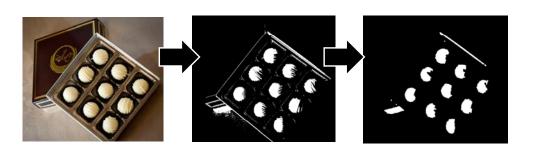


r > 230, g > 200, b > 150

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## **Change Threshold** [= =!]



r > 200, g > 170, b > 120

**Change Threshold** [= =!]



r > 200, g > 170, b > 120

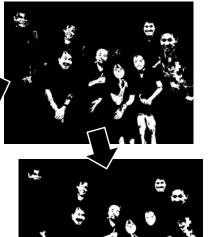
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**Skin Detection** 



Try Color Thresholding in HSV space



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