

Modely farieb

Referenčný model:

CIE XYZ

HW závislé:

RGB, CMYK, televízne normy

Užívateľsky orientované:

HLS, HSV, HSI

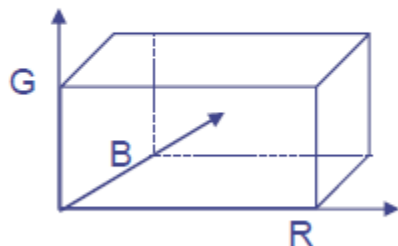
Vnemoivo rovnomerné (perceptually uniform) :

CIE Lab, Luv, WUV

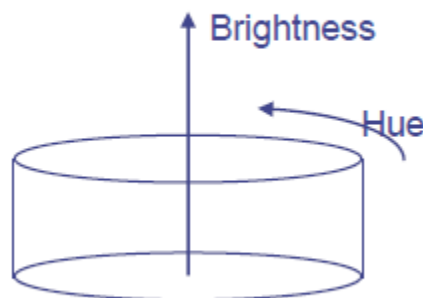
Iné:

oponent, TSV, LUX, YES, ...

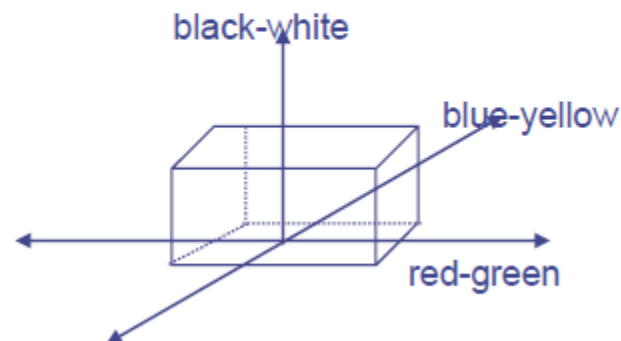
Cubic Color Spaces



Polar Color Spaces



Oponent Color Spaces



CIE XYZ

CIE 1931

Medzinárodná komisia pre svetlo

trojica primárnych farieb X, Y, Z

nereálne, supersaturované ($> 100\%$)

všetky farby sa dajú vyrobiť **pozitívnou** kombináciou X, Y, Z

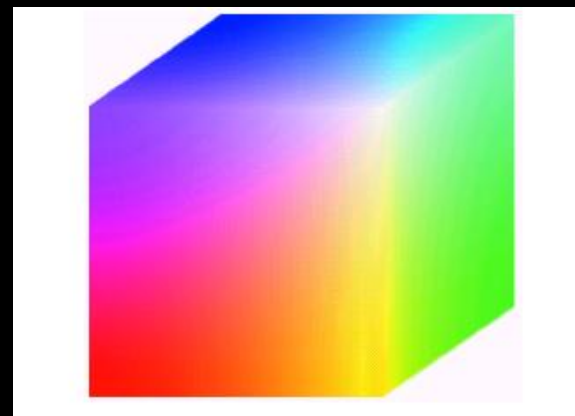
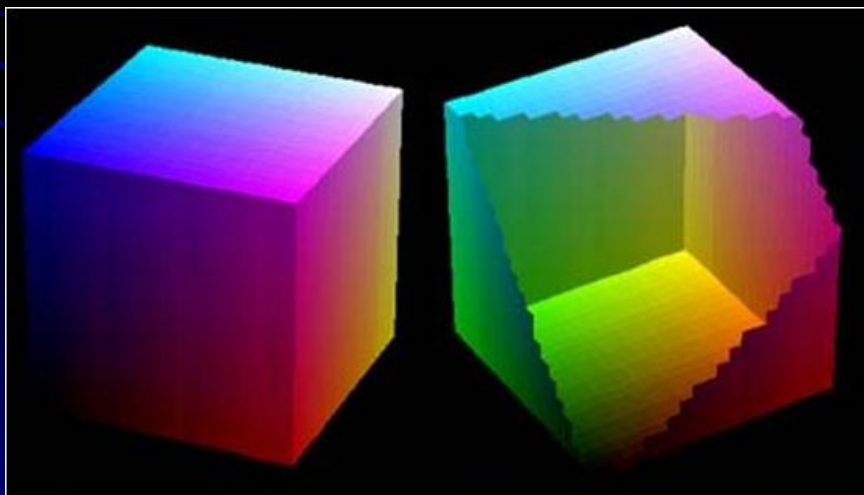
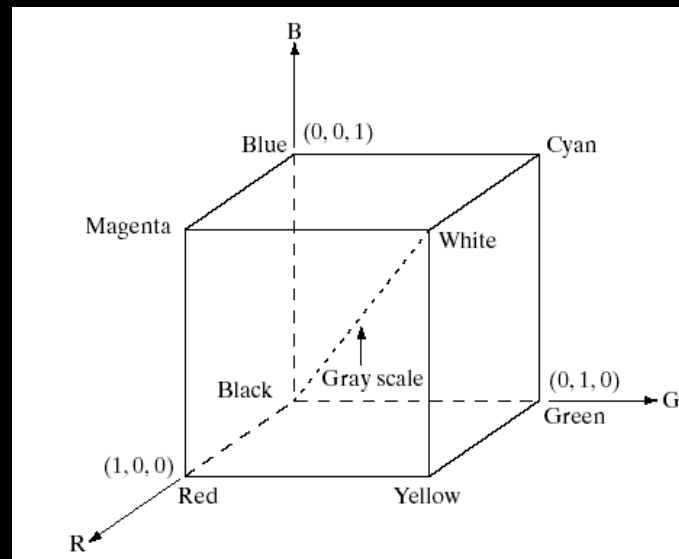
Y zodpovedá intenzite L

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.412453 & 0.357580 & 0.180423 \\ 0.212671 & 0.715160 & 0.072169 \\ 0.019334 & 0.119193 & 0.950227 \end{bmatrix} \begin{bmatrix} R_{709} \\ G_{709} \\ B_{709} \end{bmatrix}$$

RGB

Najznámejší model
Používaný v monitoroch
Farebné svetlá

Hodnoty $R, G, B \in \langle 0, 1 \rangle$
Kocka



Modely RGB

CIE RGB – E

NTSC – pôvodne C, teraz D65

EBU (European Broadcast Union) – C alebo D65

CCIR (Comité Consultatif International des Radiocommunications) – D65

SMPTE (Society of Motion Picture and Television Engineers) – D65

TABLE 3.5-2. XYZ Chromaticity Coordinates of Standard Primaries

Standard		x	y	z
CIE	R_C	0.640000	0.330000	0.030000
	G_C	0.300000	0.600000	0.100000
	B_C	0.150000	0.060000	0.790000
NTSC	R_N	0.670000	0.330000	0.000000
	G_N	0.210000	0.710000	0.080000
	B_N	0.140000	0.080000	0.780000
SMPTE	R_S	0.630000	0.340000	0.030000
	G_S	0.310000	0.595000	0.095000
	B_S	0.155000	0.070000	0.775000
EBU	R_E	0.640000	0.330000	0.030000
	G_E	0.290000	0.600000	0.110000
	B_E	0.150000	0.060000	0.790000
CCIR	R_R	0.640000	0.330000	0.030000
	G_R	0.300000	0.600000	0.100000
	B_R	0.150000	0.060000	0.790000

Modely farieb “triedy Y”

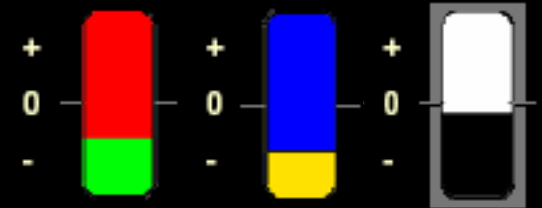
Televízne a video štandardy

YIQ – NTSC

YUV – PAL

YCbCr – digital

YCC – Kodak



Farebná zložka oddelená od jasovej (Y)

Farebná zložka: zeleno/červený kanál

žltý/modro kanál

Vo všeobecnosti:

$$Y' = 0.299R' + 0.587G' + 0.114B'$$

$$C_1 = a_1(R' - Y') + b_1(B' - Y')$$

$$C_2 = a_2(R' - Y') + b_2(B' - Y'),$$

$$\begin{bmatrix} Y' \\ C_1 \\ C_2 \end{bmatrix} = M * \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix}$$

Lineárne vzťahy

Color space	Matrix/coefficients
YC_bC_r	$\begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.168736 & -0.331264 & 0.5 \\ 0.5 & -0.418668 & -0.081312 \end{bmatrix}$
YCC	$\begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.299 & -0.587 & 0.886 \\ 0.701 & -0.587 & -0.114 \end{bmatrix}$
YIQ	$\begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.59597799 & -0.27417610 & -0.32180189 \\ 0.21147017 & -0.52261711 & 0.31114694 \end{bmatrix}$
YUV	$a_1 = 0 \quad b_1 = 1/2.03$ $a_2 = 1/1.14 \quad b_2 = 0$

Polárne súradnice

$$Hue = \tan^{-1} \left(\frac{C_2}{C_1} \right)$$

$$Saturation = \sqrt{C_1^2 + C_2^2}$$

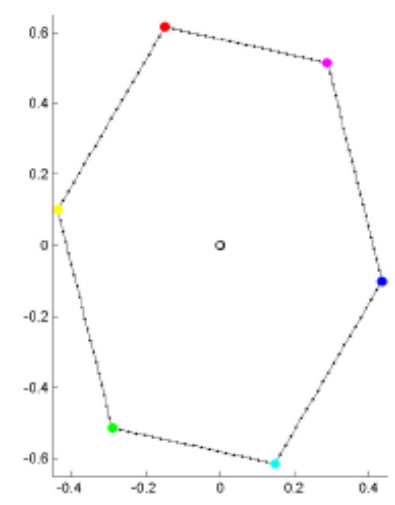
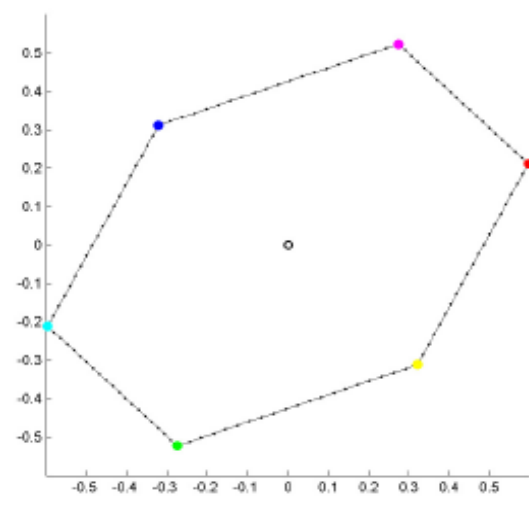
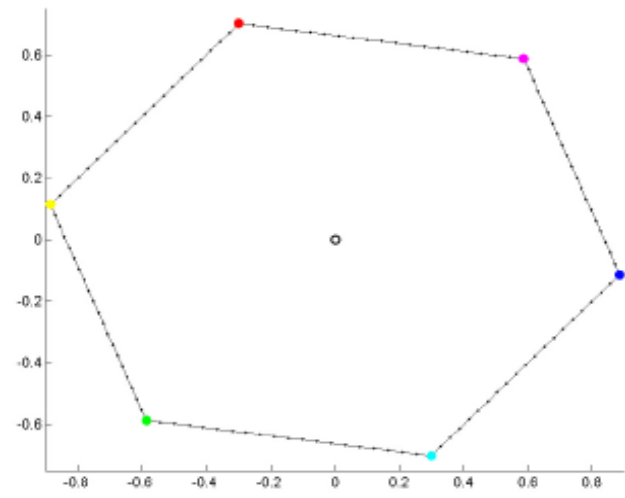
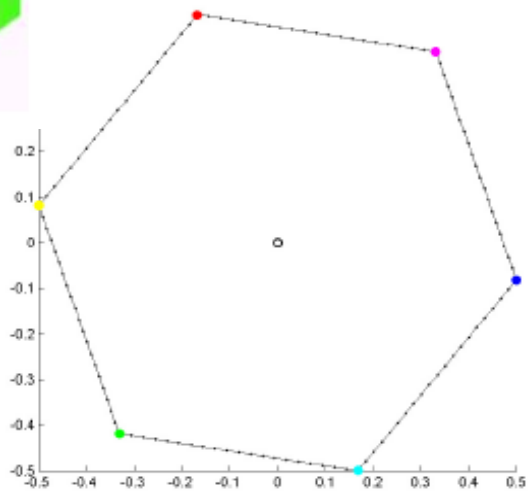
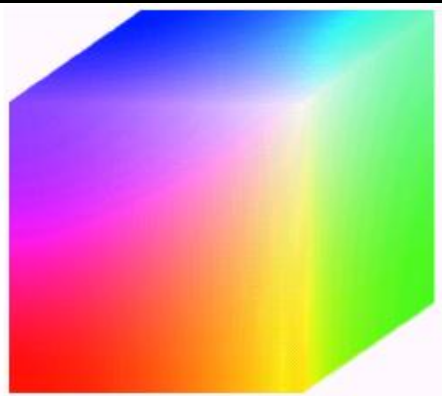


Figure 1.18: Class Y' color spaces. Projection along the Y' axis. a) YC_bC_r , b) YCC , c) YIQ , d) YUV .

Užívateľsky orientované modely

Analógia s maliarskym pohľadom
(odtieň, sýtosť, jas)

Vhodné pre vizualizáciu (color maps)

Nelineárny prevod z/do RGB

Tvar: kužeľ (aj dvojitý), ihlan, niekedy valec

Zmena
odtieňa



sýtosť

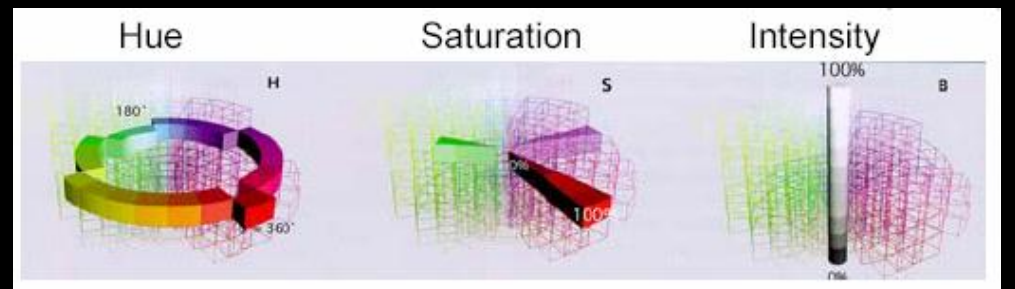
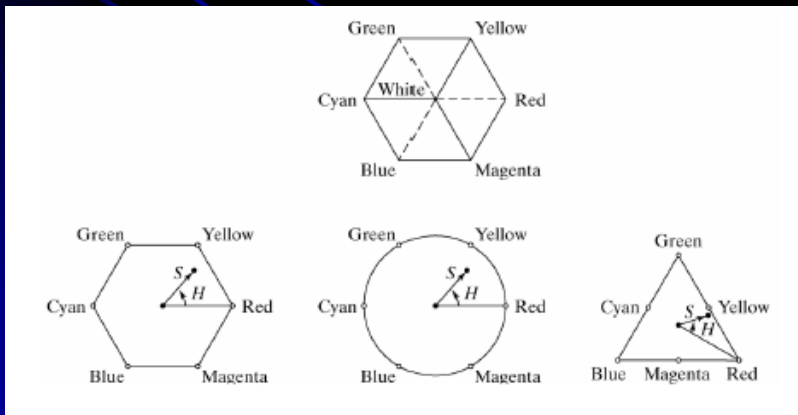
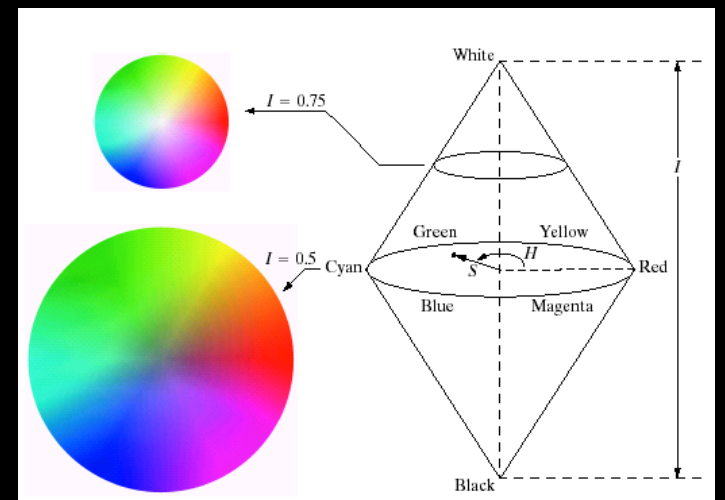
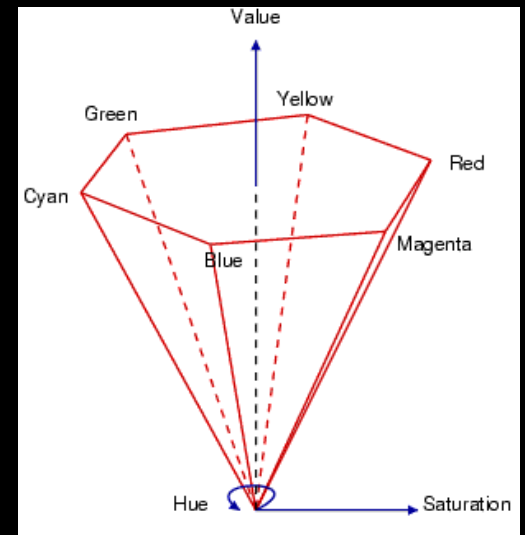
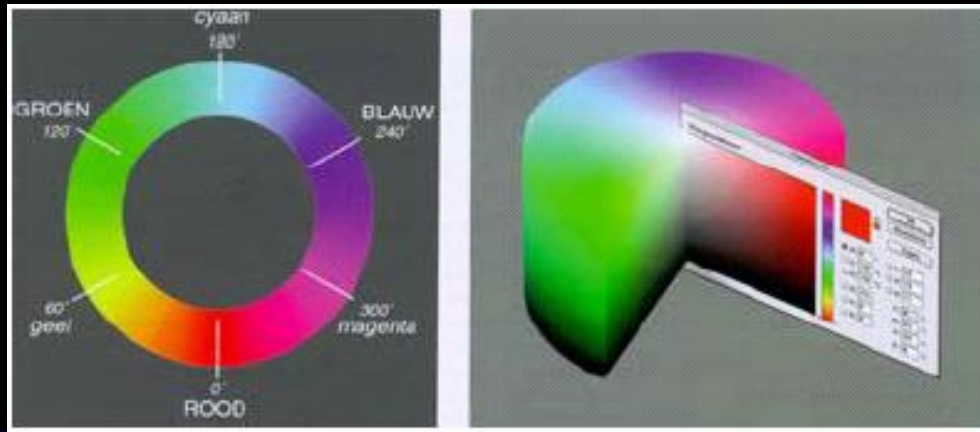


jasu



Tvary

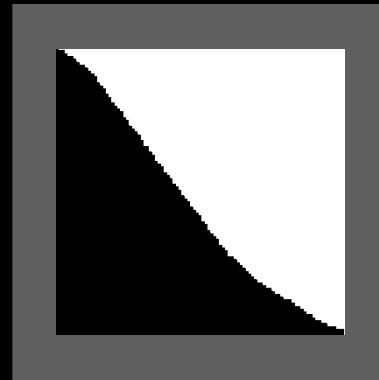
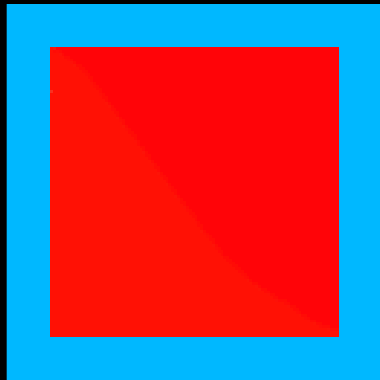
HLS, HSV, HSI



Problém?

$$H = 1^\circ$$

$$H = 359^\circ$$

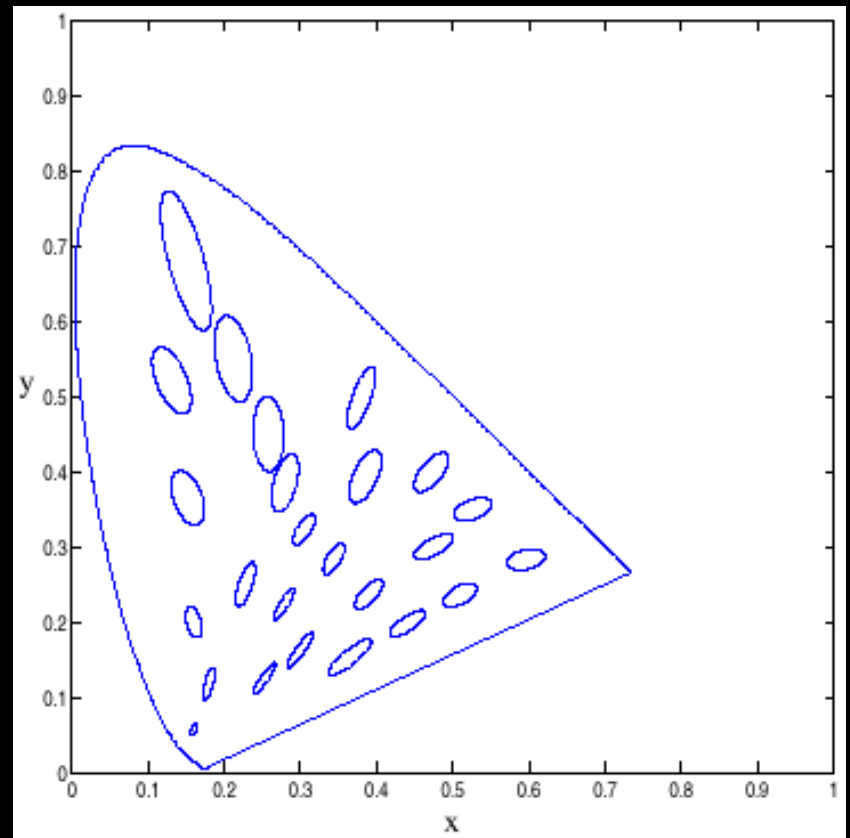


Vnemoivo rovnomerné modely

V doteraz spomínaných modeloch:

Euklidovská vzdialenosť farieb nezodpovedá vizuálnej „vzdialenosti“

McAdamove elipsy v xy –
pre pozorovateľa
nerozlíšiteľné farby



CIE L*a*b*

L* - jas

a*, b* - farebné súradnice

n – súradnice bieleho bodu

Používaný v priemysle

$$L^* = \begin{cases} 116 \left(\frac{Y}{Y_n} \right)^{\frac{1}{3}} - 16 & \text{ak } \frac{Y}{Y_n} > 0.008856 \\ 903.3 \frac{Y}{Y_n} & \text{ak } \frac{Y}{Y_n} \leq 0.008856 \end{cases}$$

$$a^* = 500 \left(f \left(\frac{X}{X_n} \right) - f \left(\frac{Y}{Y_n} \right) \right)$$

$$b^* = 200 \left(f \left(\frac{Y}{Y_n} \right) - f \left(\frac{Z}{Z_n} \right) \right)$$

$$f(t) = \begin{cases} t^{\frac{1}{3}} & \text{ak } t > 0.008856 \\ 7.787t + \frac{16}{116} & \text{ak } t \leq 0.008856 \end{cases}$$

Vzdialenosť farieb

Euklidovská vzdialenosť

CIE L*a*b*

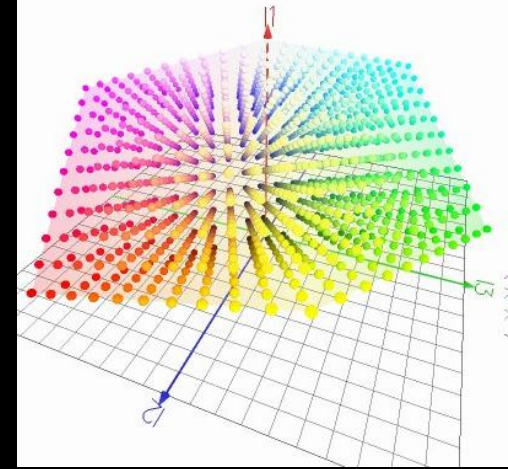
The diagram illustrates the derivation of the CIE L*a*b* color difference formula. It shows two equations. The top equation is the Euclidean distance formula: $\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$. The bottom equation is the CIE L*a*b* color difference formula: $\Delta E_{Lab}^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$. The diagram uses arrows to show the substitution of L* for L, a* for a, and b* for b in the Euclidean formula to arrive at the CIE formula.

ΔE_{Lab}^*	Effect
< 3	Not perceptible
$3 < 6$	Perceptible, but acceptable
> 6	Not acceptable

Iné

11213 (Ohta) – oponent model
lineárna transformácia

$$\begin{aligned} I_1 &= (R + G + B)/3 \\ I_2 &= R - G \\ I_3 &= B - \frac{R + G}{2}. \end{aligned}$$



$$\begin{aligned} L &= (R + 1)^{0.3}(G + 1)^{0.6}(B + 1)^{0.1} - 1 \\ U &= \begin{cases} \frac{M}{2} \frac{R+1}{L+1} & R < L \\ M - \frac{M}{2} \frac{L+1}{R+1} & \text{otherwise} \end{cases} \\ X &= \begin{cases} \frac{M}{2} \frac{B+1}{L+1} & B < L \\ M - \frac{M}{2} \frac{L+1}{B+1} & \text{otherwise,} \end{cases} \end{aligned}$$

contrast enhancement
logarithmic image processing

$$\hat{U} = \begin{cases} 256 \frac{G}{R} & R > G \\ 255 & \text{otherwise.} \end{cases}$$

Log-oponent

$$\begin{aligned} I &= L(G) \\ R_g &= L(R) - L(G) \\ B_y &= L(B) - \frac{L(G) + L(R)}{2}, \end{aligned}$$

$$\begin{bmatrix} Y \\ E \\ S \end{bmatrix} = \begin{bmatrix} 0.253 & 0.684 & 0.065 \\ 0.5 & -0.5 & 0 \\ 0.25 & 0.25 & -0.5 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

XEROX – IR imagery

Iné

$$T = \arctan(r'/g')/\pi + 1/2$$

$$S = [9/5(r'^2 + g'^2)]^{1/2}$$

$$V = (R + G + B)/3,$$

$$r' = (r - 1/3)$$

$$g' = (g - 1/3)$$

„Modrá = 0“

$$\begin{bmatrix} I \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\ \frac{-1}{\sqrt{6}} & \frac{-1}{\sqrt{6}} & \frac{2}{\sqrt{6}} \\ \frac{1}{\sqrt{6}} & \frac{-1}{\sqrt{6}} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$H = \arctan\left\{\frac{V_2}{V_1}\right\}$$

$$S = (V_1^2 + V_2^2)^{1/2}$$

$$T = \begin{cases} \arctan(r'/g')/2\pi + 1/4 & g' > 0 \\ \arctan(r'/g')/2\pi + 3/4 & g' < 0 \\ 0 & g' = 0 \end{cases}$$

$$S = [9/5(r'^2 + g'^2)]^{1/2}$$

$$L = 0.299R' + 0.587G' + 0.114B',$$

„uhlové“ modely

photometric color invariant model $l_1 l_2 l_3$

$$l_1 = \frac{(R-G)^2}{(R-G)^2 + (R-B)^2 + (G-B)^2}, l_2 = \frac{(R-B)^2}{(R-G)^2 + (R-B)^2 + (G-B)^2}, l_3 = \frac{(G-B)^2}{(R-G)^2 + (R-B)^2 + (G-B)^2}$$

MPEG7 - HMMD

HMMD

hue, min, max, diff

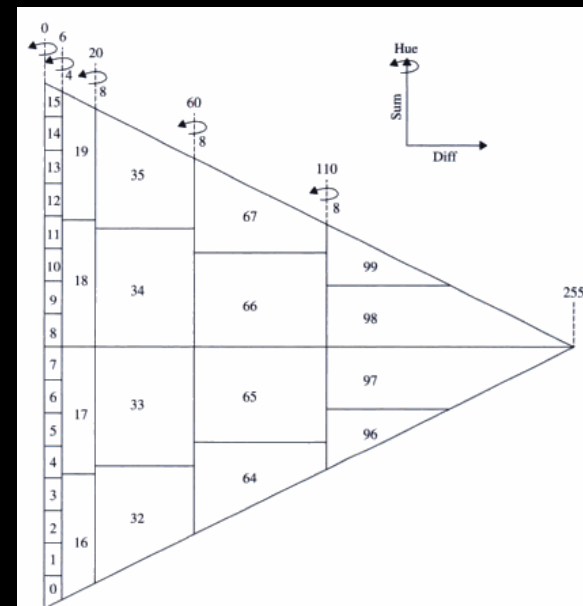
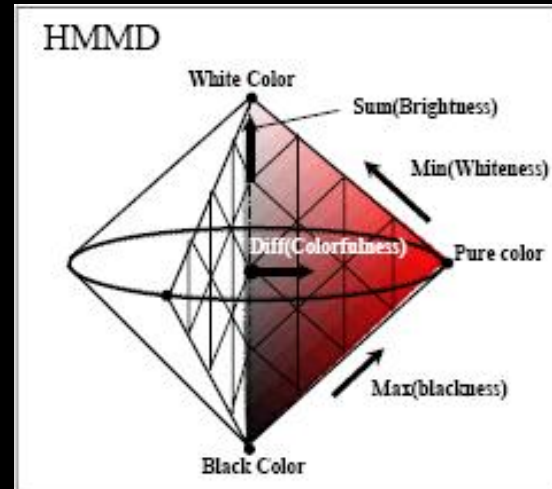
$\min = \min(R, G, B)$

$\max = \max(R, G, B)$

$\text{sum} = (\max + \min) / 2$

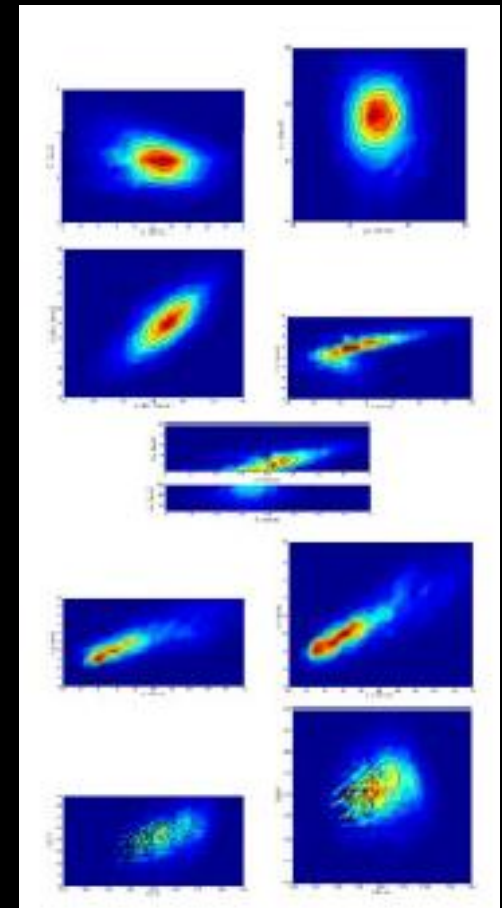
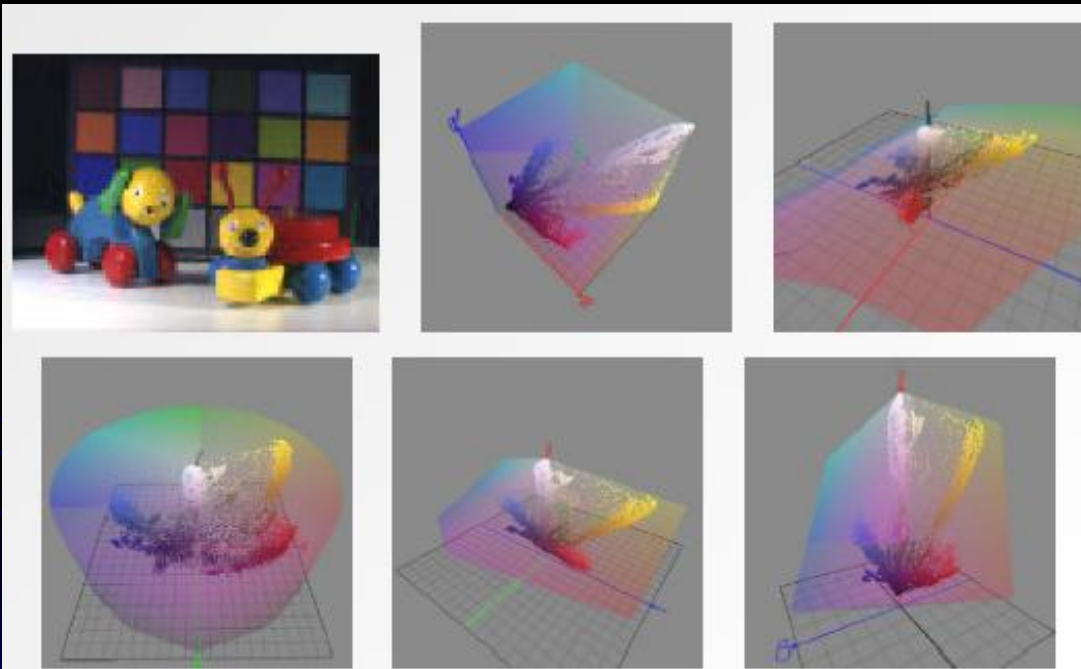
$\text{diff} = \max - \min$

hue – ako v HSV



Použitie modelov

Ľudské tváre



RGB to Gray

Color2Gray: Saliency-Preserving Color Removal

Amy A. Gooch

Sven C. Olsen

Jack Tumblin

Bruce Gooch

Northwestern University *



(a) CIECAM97 Lum



(b) $L^*a^*b^*$ Lum.



(c) XYZ Lum.



(d) YCrCb Lum.



(e) Auto Contrast



(f) Color2Gray

89648 různých
RGB trojíc



Kvantovanie

- Preskúmanie originálneho obrazu, zistenie informácií o použitých farbách
- Určenie palety na základe týchto informácií
- Namapovanie farieb na vybrané reprezentatívne farby
- Vykreslenie nového (kvantovaného) obrazu



Algoritmus



Mapovanie...



Kvantovanie

podľa prístupu k informáciám

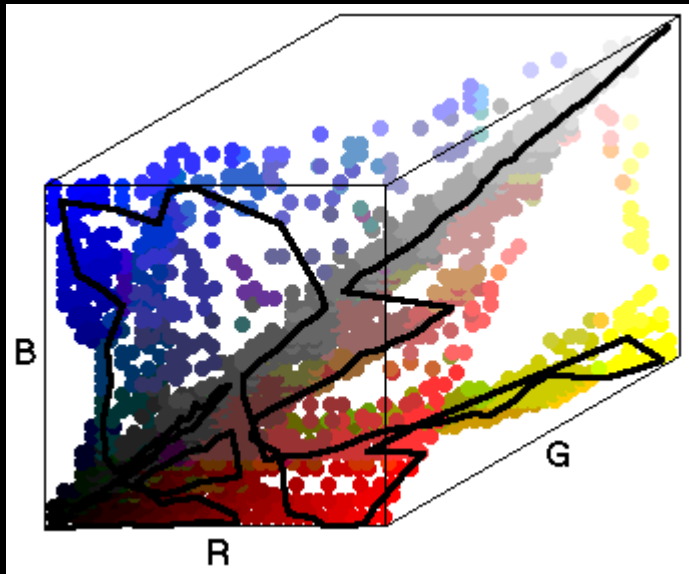
Obrazovo nezávislé:

Paleta reprezentatívnych farieb rovnaká pre všetky obrazy

Obrazovo závislé:

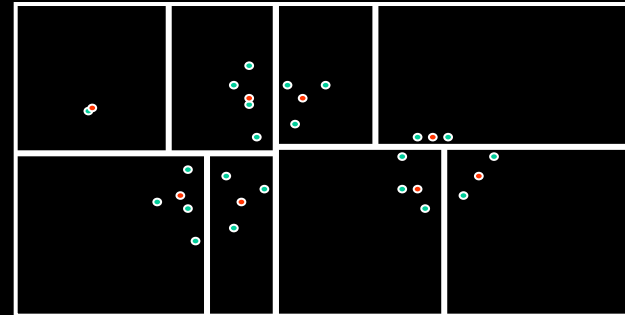
- Paleta reprezentatívnych farieb pre konkrétny obraz

Kombinácia?

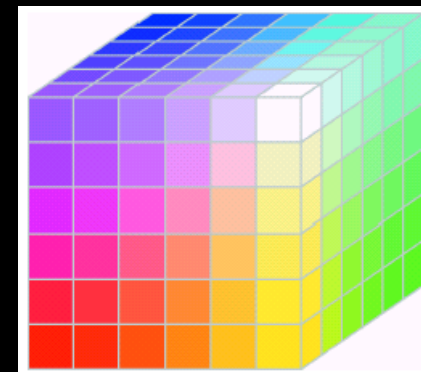


neuquant

Median cut



Rozdelenie priestoru farieb závisí od skutočného rozloženia farieb v obraze.



Priestor farieb je rozdelený na pravidelné regióny, bez ohľadu na farebné vlastnosti obrazu.

neuquant



4



32



256

8

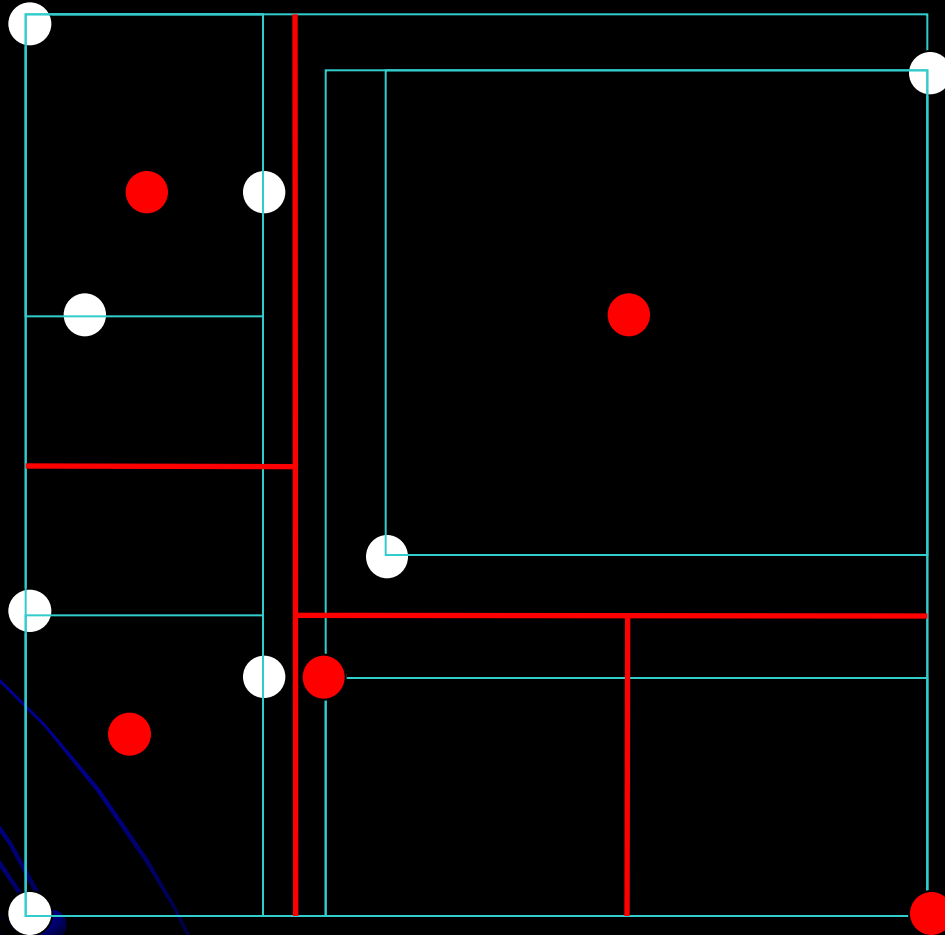


Algoritmus rozdelenia podľa mediánu (median cut)

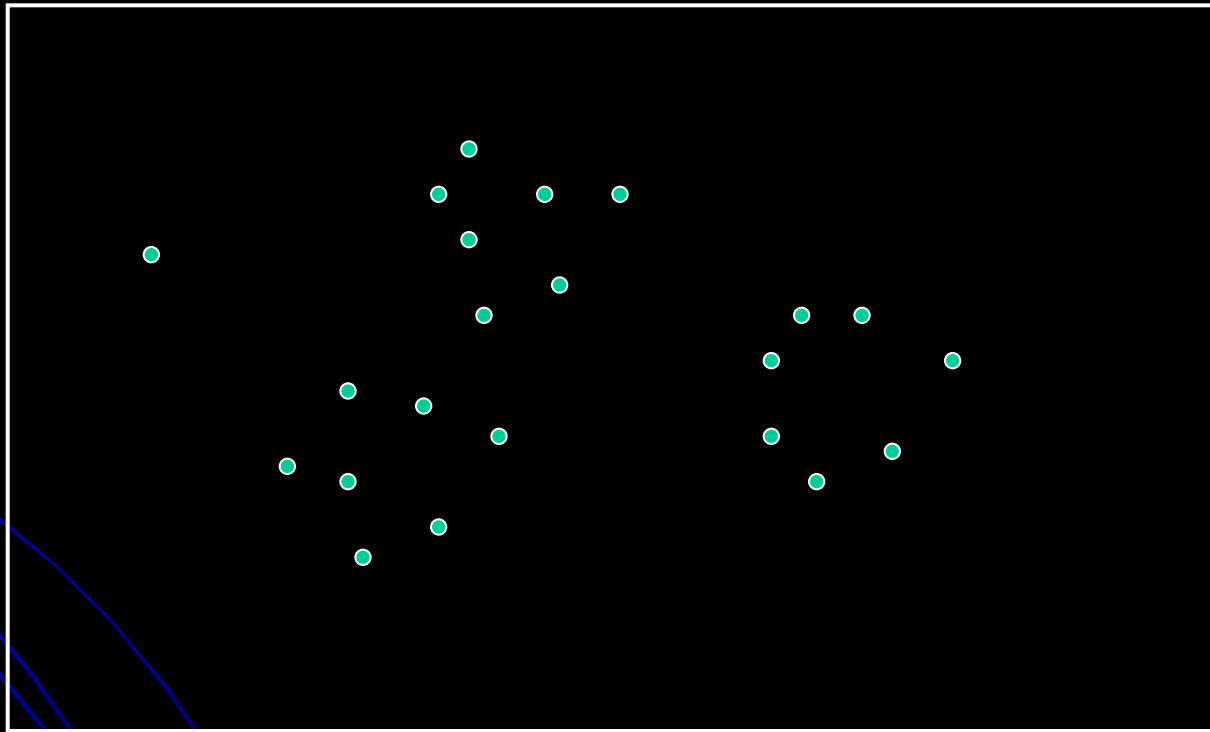
Koncept – reprezentatívne farby zatupujú približne rovnaký počet pôvodných farieb

nájdí najmenší obal obsahujúci všetky farby
zorad' farby podľa najdlhšej osi
rozdeľ obal v bode mediánu
opakuj, kým nemáme K farieb

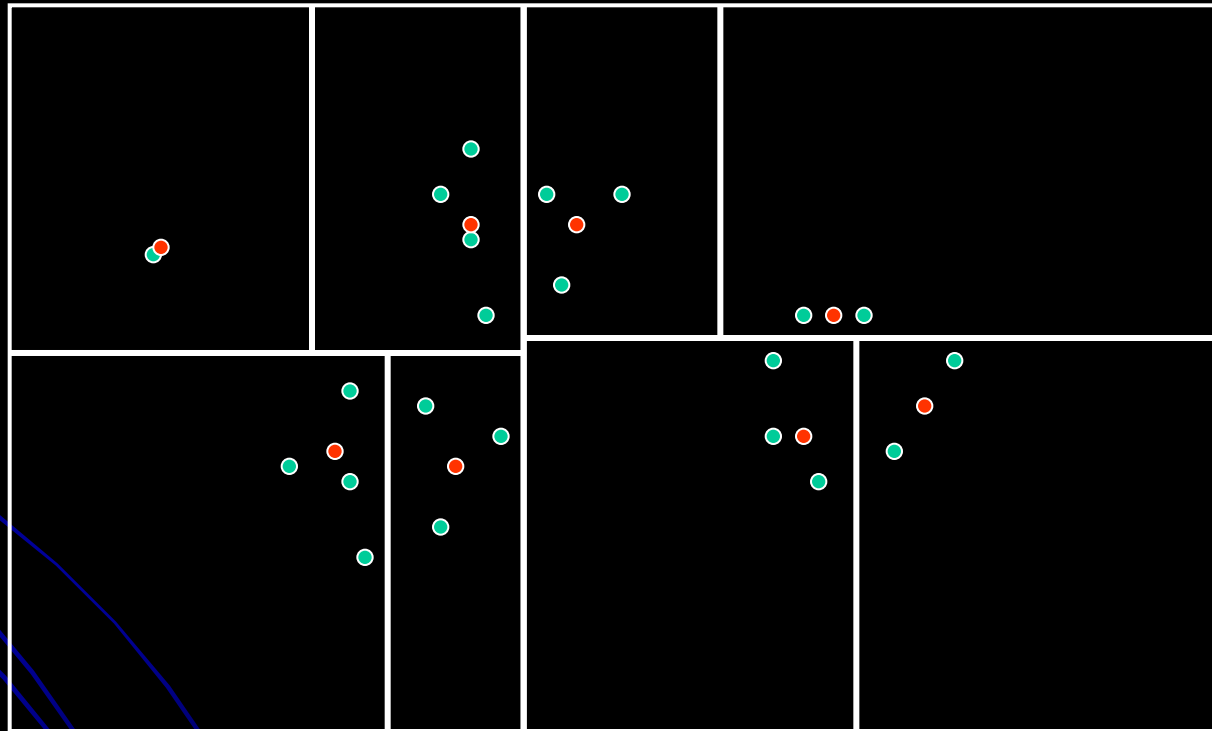
Median Cut



Median Cut

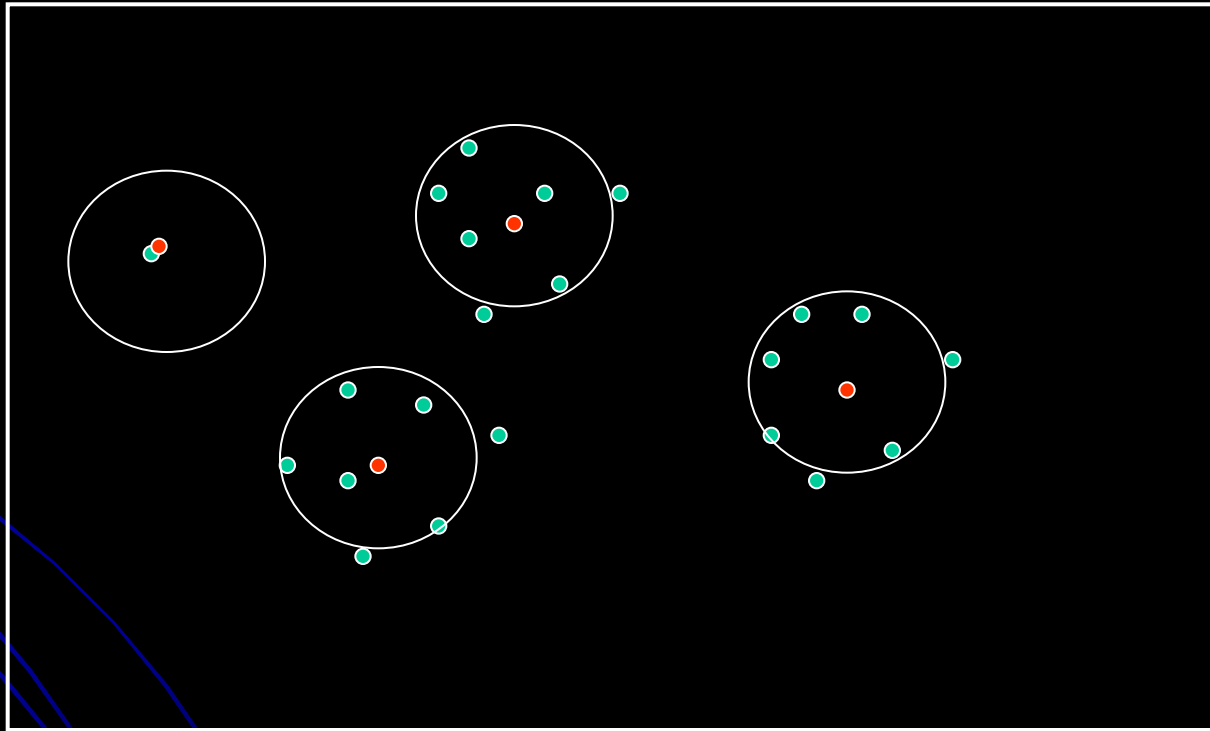


Median Cut



Lepšie riešenie

median-cut, potom k-means, potom zlúčiť blízke zhluky ($d(c_i, c_j) < t$)





4

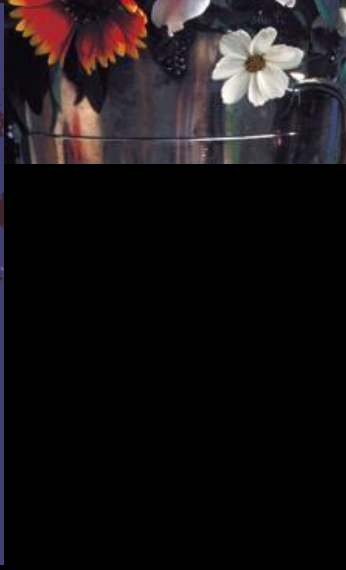
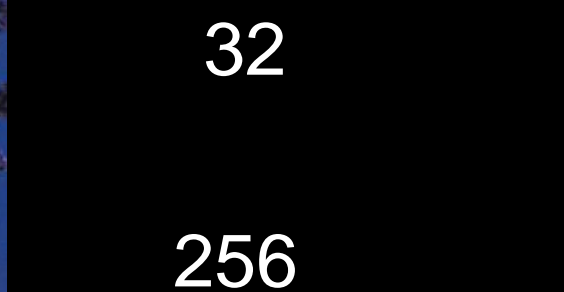
8

Median cut



32

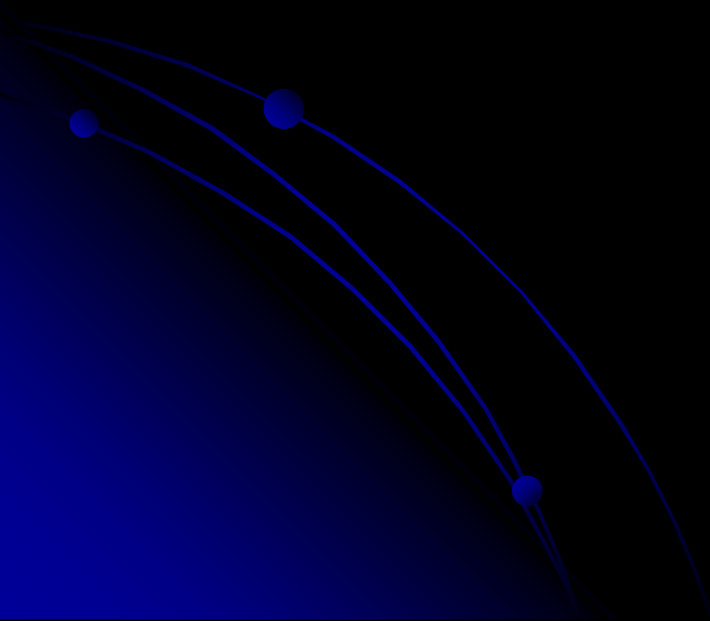
256



Príznaky - Features

Originálne dáta -> príznaky
zníženie počtu spracovávaných dát

Príznak – vektor príznakov



Príznaky

Nízka úroveň - low level

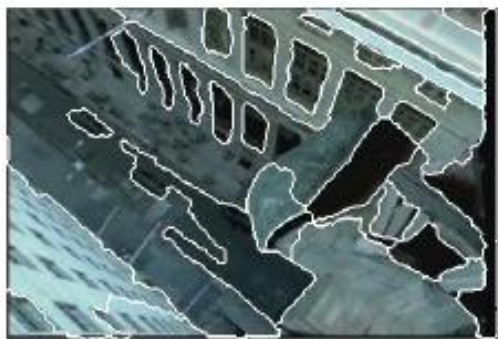
Tvar, textúra, farba

Stredná úroveň – mid, intermediate

Kontrast, jednotlivé tvary, tváre...

Vysoká úroveň - high

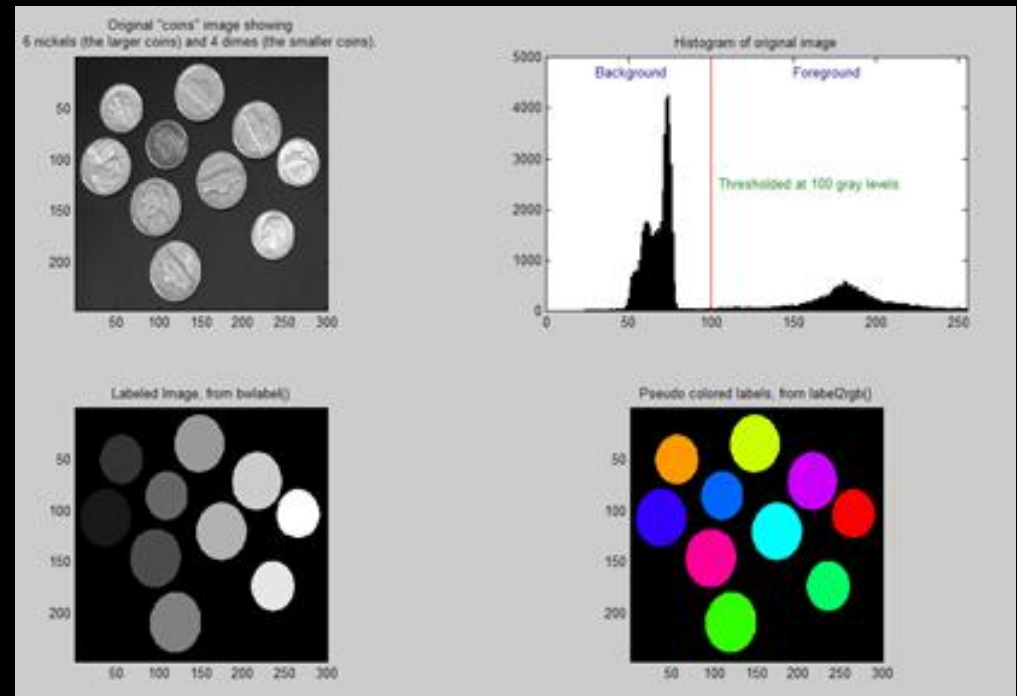
Sémantika



Identifikácia oblastí

jednoznačné označenie jednotlivých oblastí obrazu
(farbenie oblastí)

oblasti a pozadie, pričom pozadie je reprezentované nulou
a objekty nenulovými hodnotami



algoritmus

1. prechod

Skenuje obrázok, nájde bod obrazu

- ak sú susedné pixle určenej masky nulové, priradí mu nové označenie
- ak jeden je nenulový, alebo všetky nenulové majú rovnaké označenie, priradí mu toto označenie
- ak ich je viac rôzne nenulových, vyberie ľubovoľné označenie a poznačí si kolíziu farieb do tabuľky ekvivalencie

4/8-susednosť

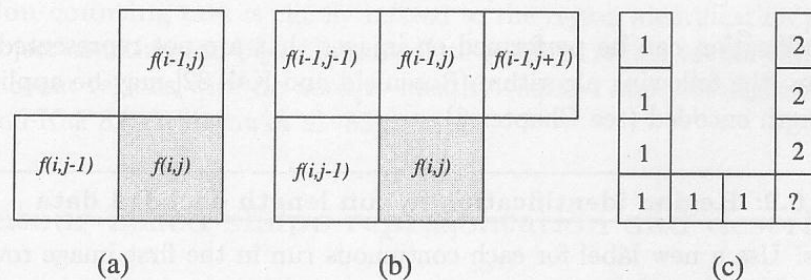
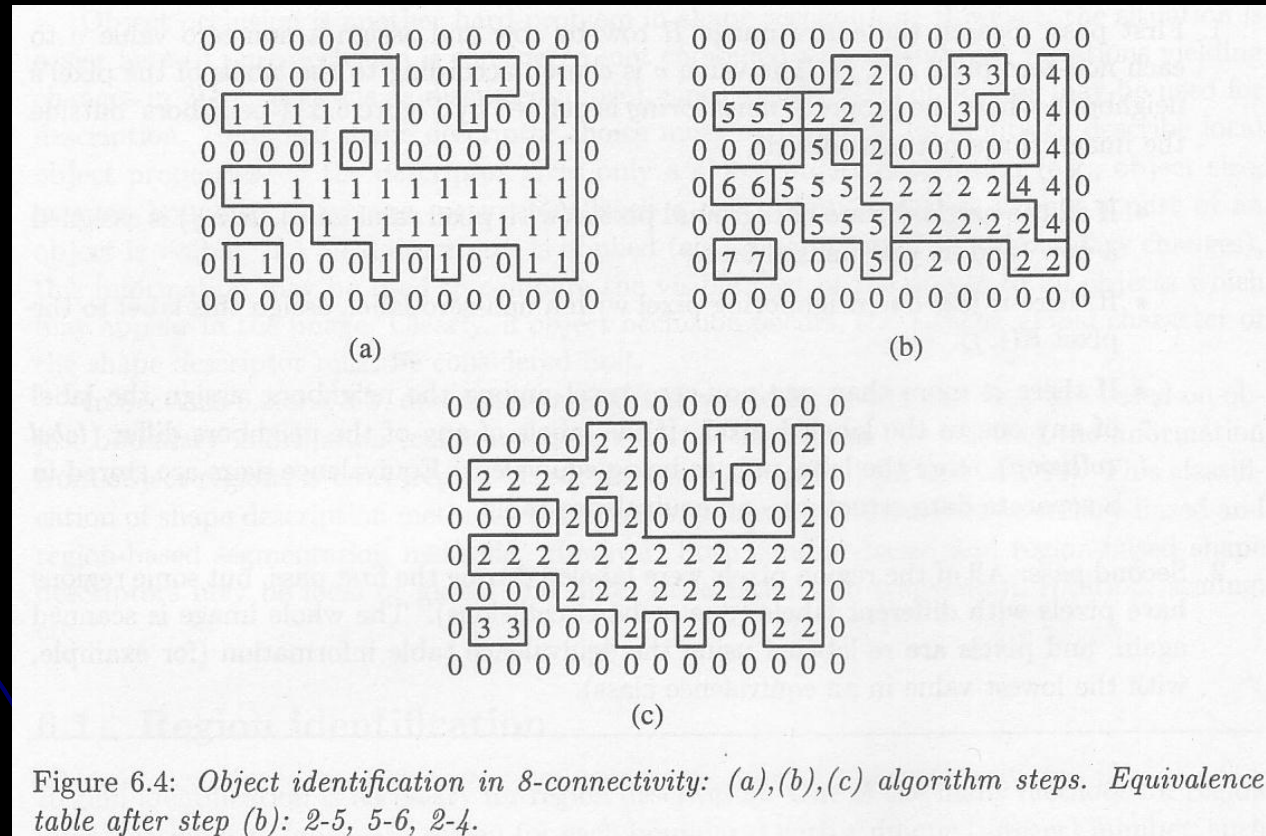


Figure 6.3: Masks for region identification: (a) in 4-connectivity; (b) in 8-connectivity; (c) label collision.

algorithmus

2. prechod

Skenuje obrázok, zjednotí označenie podľa tabuľky ekvivalencie



K-means segmentácia

X_1, \dots, X_N – intenzita bodov obrazu

Každý bod priradený jednej oblasti

$C(i)$ oblasť do ktorej i -ty bod patrí

K-means minimalizuje vnútroklastrovú vzdialenosť:

$$W(C) = \frac{1}{2} \sum_{k=1}^K \sum_{C(i)=k} \sum_{C(j)=k} \|x_i - x_j\|^2 = \sum_{k=1}^K N_k \sum_{C(i)=k} \|x_i - m_k\|^2$$

m_k priemer klastra k

N_k počet bodov v klastri k

K-means Algorithm

Pre dané priradenie C vypočítaj priemery m_k :

$$m_k = \frac{\sum_{i:C(i)=k} x_i}{N_k}, k = 1, \dots, K.$$

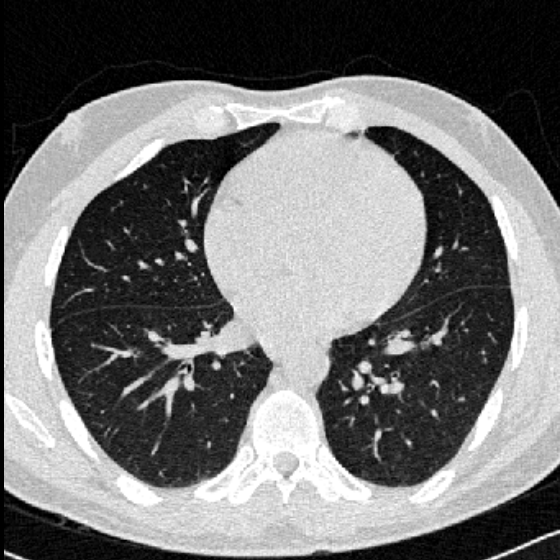
Pre nové priemery urči priradenie C :

$$C(i) = \arg \min_{1 \leq k \leq K} \|x_i - m_k\|^2, i = 1, \dots, N$$

Opakuj



Image Segmentation Results



Matlab code:

```
I = double(imread('...'));
```

```
J = reshape(kmeans(I(:),3),size(I));
```