Robotika in računalniško zaznavanje (RRZ)

Barvne slike

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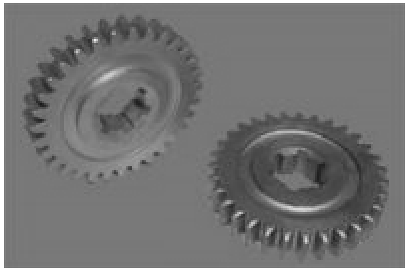
Literatura: W. Burger, M. J. Burge (2008).
Digital Image Processing, poglavje 12

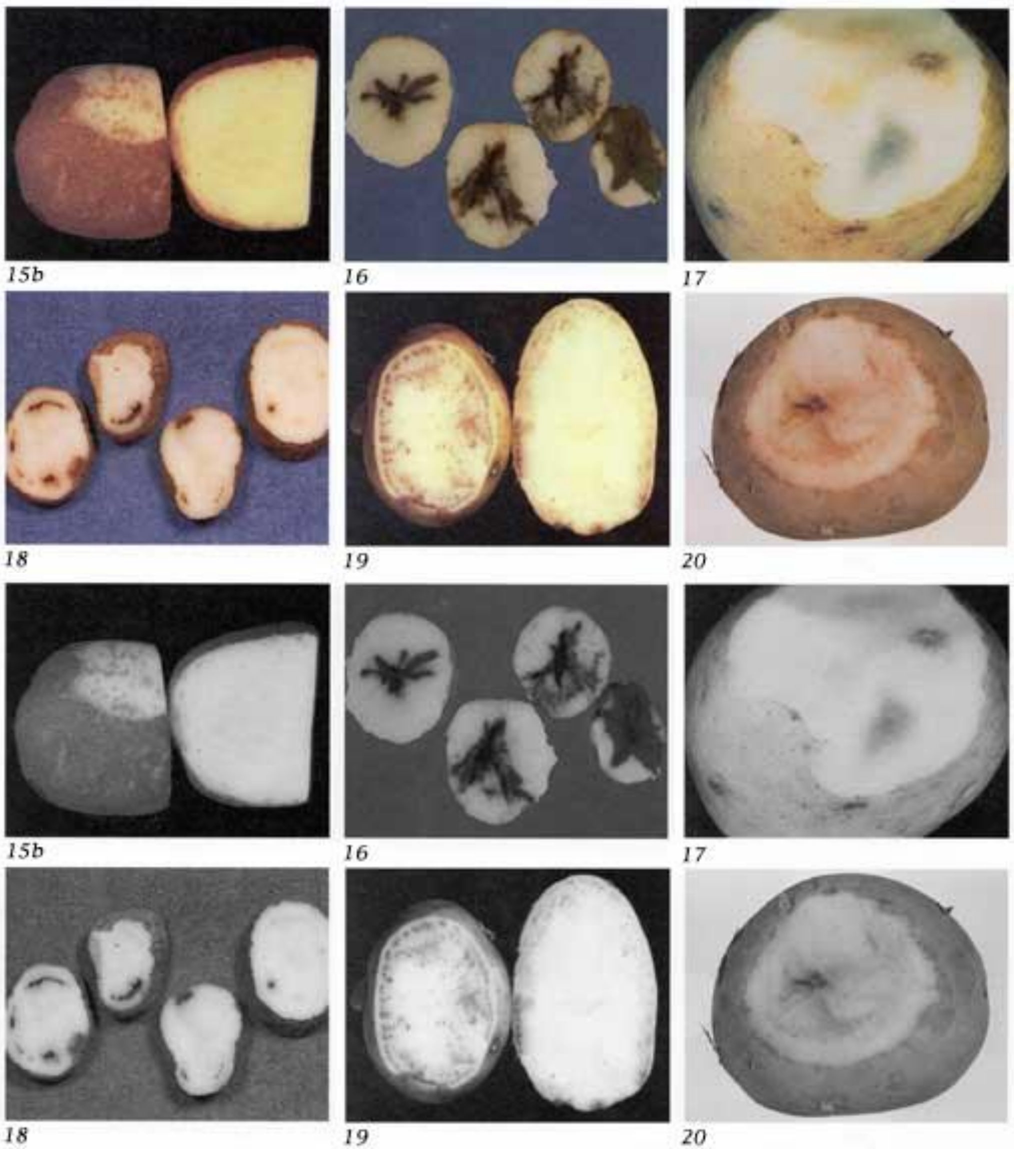
v7.0

Barvne slike

Barvne slike

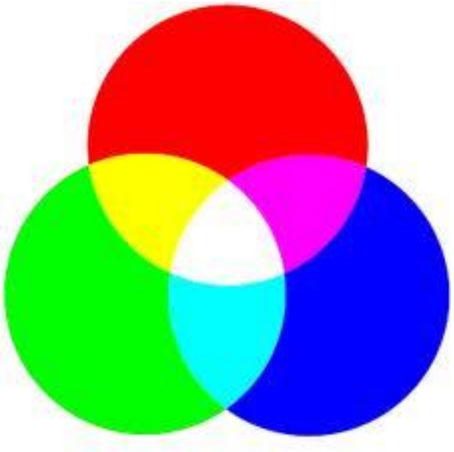
- Včasih barve nosijo pomembno informacijo!

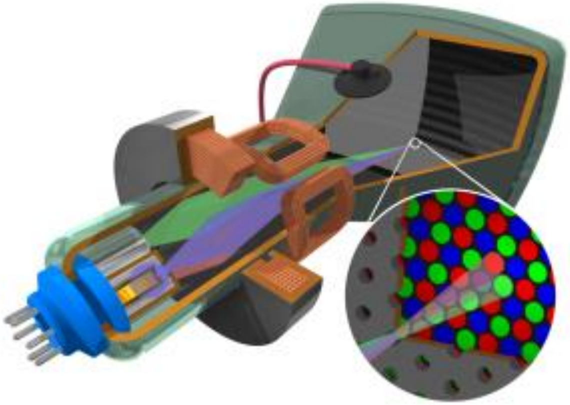




RGB barvne slike

- Barvna shema RGB kodira barve kot kombinacije treh osnovnih barv: rdeče, zelene in modre
- Zelo pogosto uporabljana
- Aditivni barvni sistem

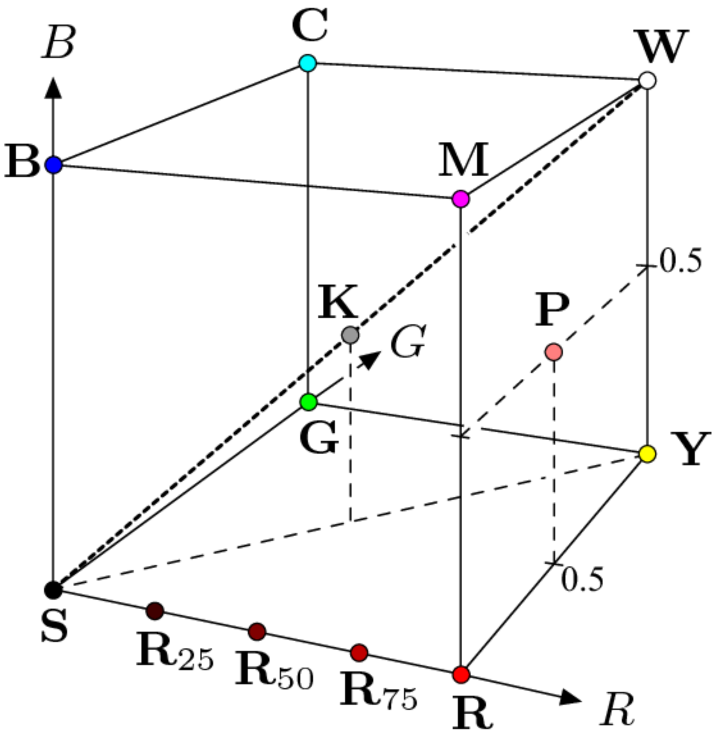




Barvni prostor RGB

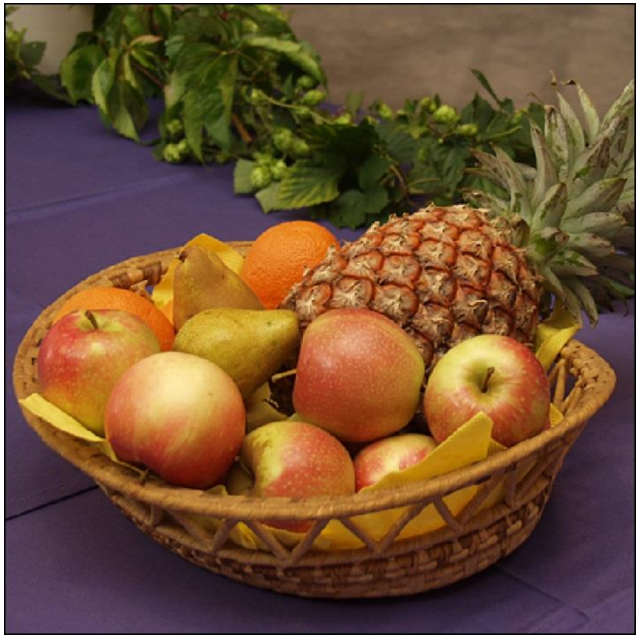
- Vsaka barva je točka v 3D RGB prostoru

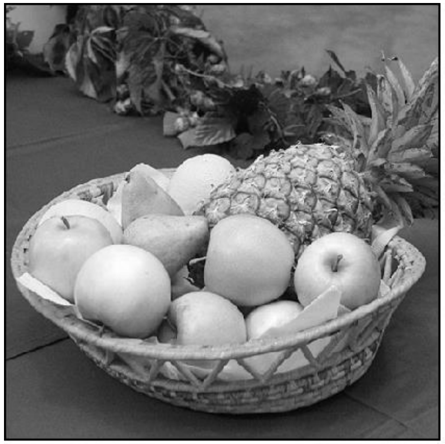
$$\mathbf{C}_i = (R_i, G_i, B_i)$$



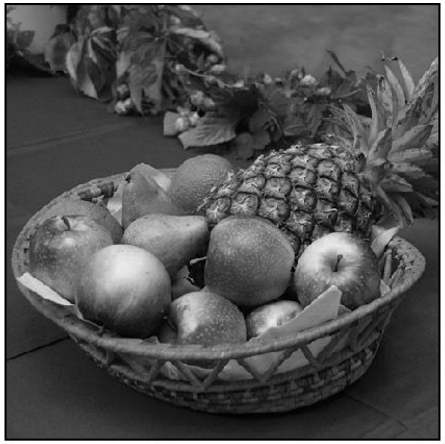
		RGB Value		
Point	Color	R	G	B
S	Black	0.00	0.00	0.00
R	Red	1.00	0.00	0.00
Y	Yellow	1.00	1.00	0.00
G	Green	0.00	1.00	0.00
C	Cyan	0.00	1.00	1.00
B	Blue	0.00	0.00	1.00
M	Magenta	1.00	0.00	1.00
W	White	1.00	1.00	1.00
K	50% Gray	0.50	0.50	0.50
$\mathbf{R}_{75}$	75% Red	0.75	0.00	0.00
$\mathbf{R}_{50}$	50% Red	0.50	0.00	0.00
$\mathbf{R}_{25}$	25% Red	0.25	0.00	0.00
P	Pink	1.00	0.50	0.50

Primer RGB kanalov

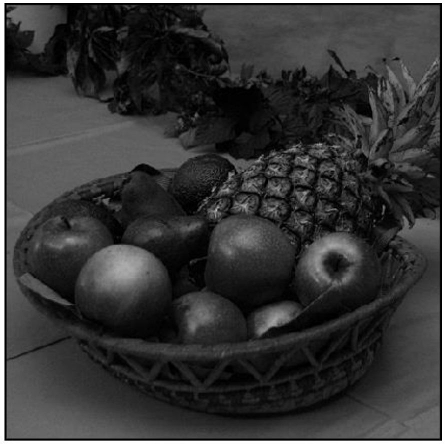




R



G



B

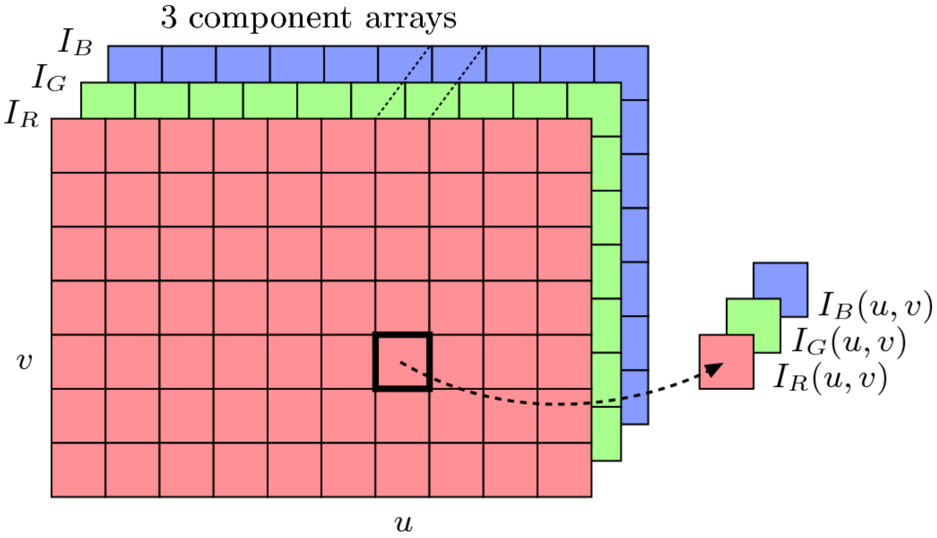
Organizacija barvnih slik

- „True color“ slike -navedene so vse tri RGB komponente

- Vrstni red po komponentah

$$I = \langle I_R, I_G, I_B \rangle$$

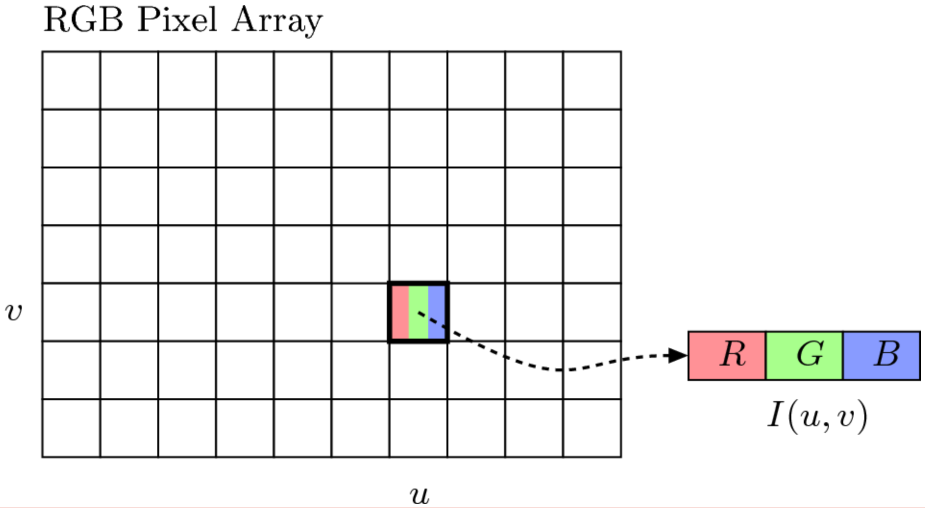
$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} \leftarrow \begin{pmatrix} I_R(u,v) \\ I_G(u,v) \\ I_B(u,v) \end{pmatrix}$$



- Paketen vrstni red

$$I(u,v) = \langle R, G, B \rangle$$

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} \leftarrow \begin{pmatrix} \mathrm{Red}(I(u,v)) \\ \mathrm{Green}(I(u,v)) \\ \mathrm{Blue}(I(u,v)) \end{pmatrix}$$

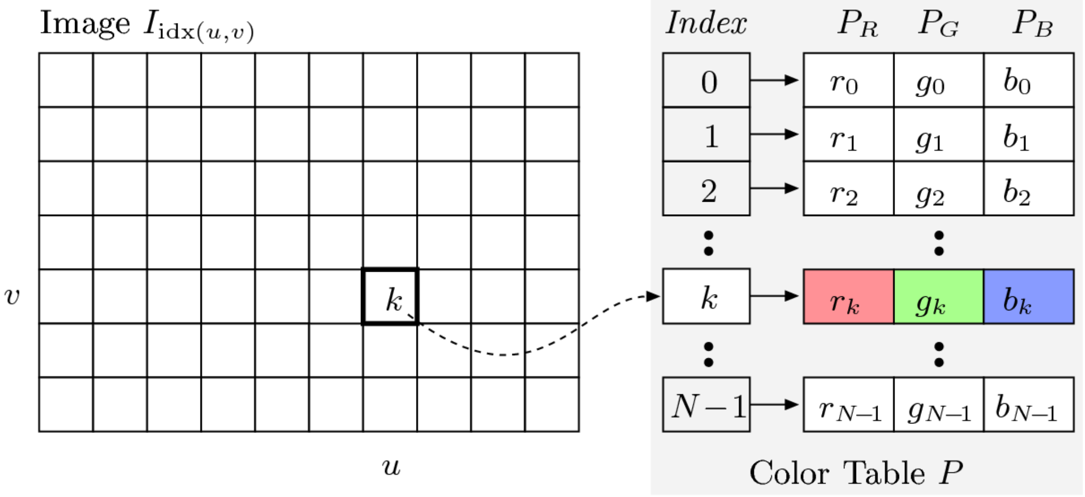


Organizacija barvnih slik

- Indeksirane slike
  - Omogočajo samo določeno število slik z barvne palete
  - Samo za shranjevanje
  - Za obdelavo jih je potrebno pretvoriti v „True color“ format

$$P[k] = (P_R[k], P_G[k], P_B[k])$$

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} \leftarrow \begin{pmatrix} P_R[k] \\ P_G[k] \\ P_B[k] \end{pmatrix} = \begin{pmatrix} r_k \\ g_k \\ b_k \end{pmatrix}$$



Konverzija v sivinske slike

- Enostavna konverzija:

$$Y = \mathrm{Avg}(R, G, B) = \frac{R+G+B}{3}$$

- Človeško oko zaznava rdečo in zeleno kot svetlejše kot modro, zato lahko uporabimo uteženo povprečje:

$$Y = \mathrm{Lum}(R, G, B) = w_R \cdot R + w_G \cdot G + w_B \cdot B$$

$$w_R = 0.299 \qquad w_G = 0.587 \qquad w_B = 0.114$$

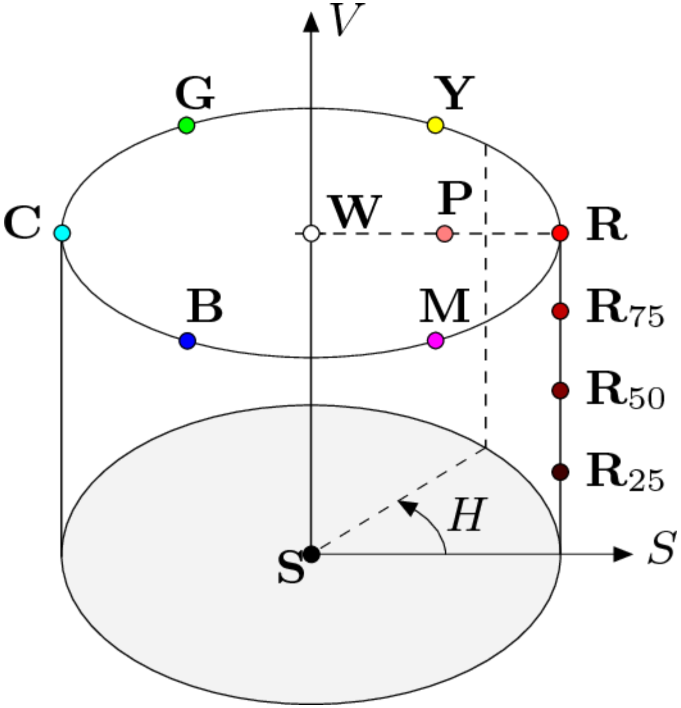
$$w_R = 0.2125 \qquad w_G = 0.7154 \qquad w_B = 0.072$$

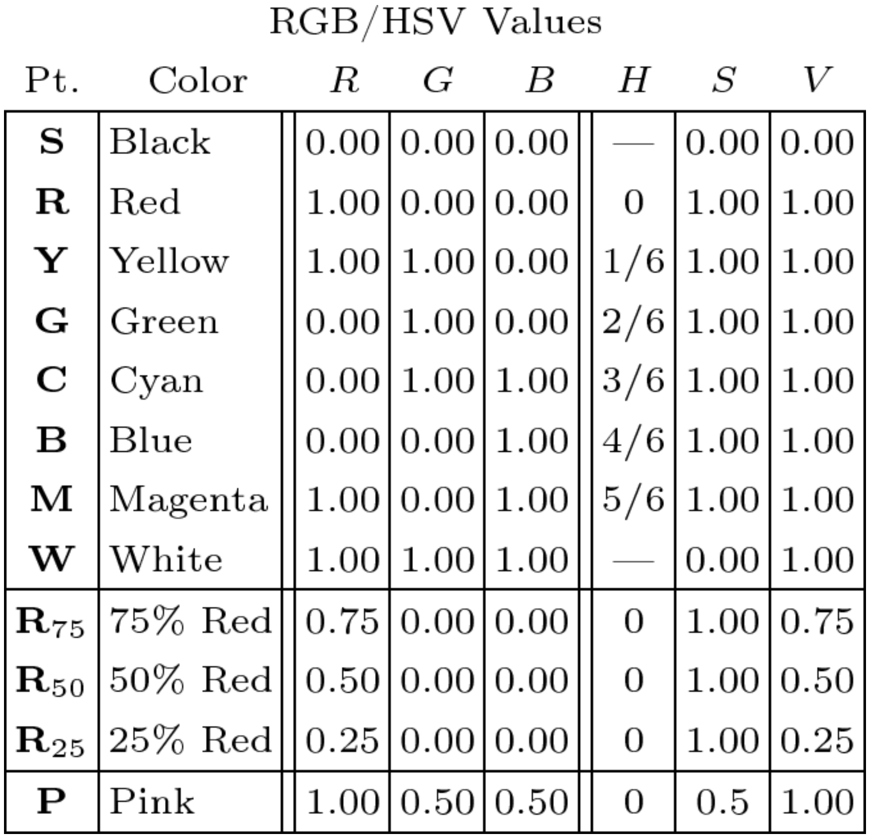
- Sivinske RGB slike imajo vse komponente enake:

$$R = G = B \qquad \begin{pmatrix} R' \\ G' \\ B' \end{pmatrix} \leftarrow \begin{pmatrix} Y \\ Y \\ Y \end{pmatrix}$$

Barvni prostor HSV

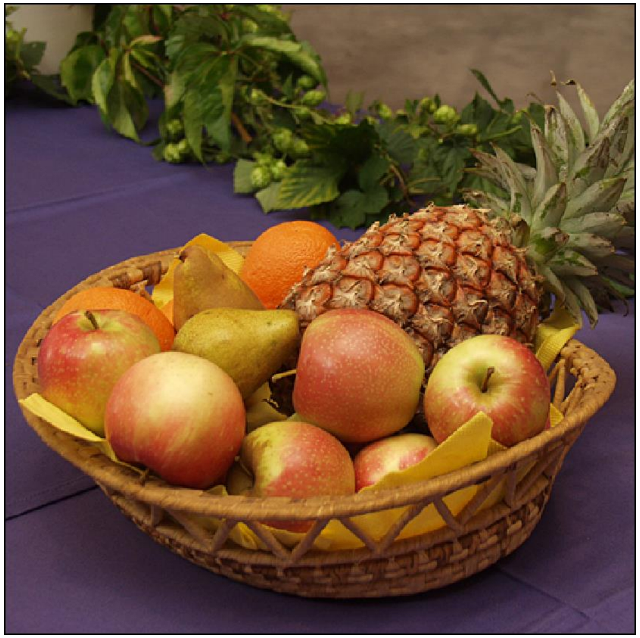
- Hue, Saturation, Value
- Odtenek, Nasičenost, Intenziteta

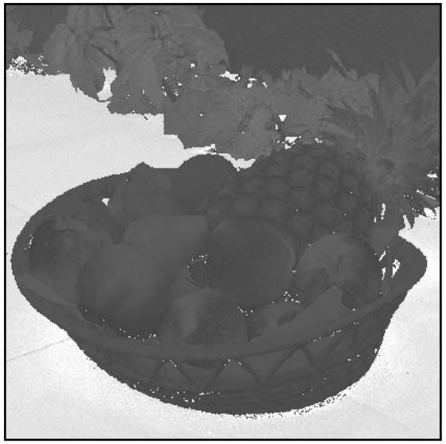



RGB/HSV Values

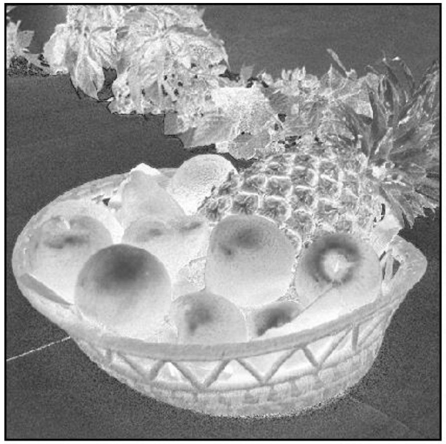
Pt.	Color	R	G	B	H	S	V
S	Black	0.00	0.00	0.00	—	0.00	0.00
R	Red	1.00	0.00	0.00	0	1.00	1.00
Y	Yellow	1.00	1.00	0.00	1/6	1.00	1.00
G	Green	0.00	1.00	0.00	2/6	1.00	1.00
C	Cyan	0.00	1.00	1.00	3/6	1.00	1.00
B	Blue	0.00	0.00	1.00	4/6	1.00	1.00
M	Magenta	1.00	0.00	1.00	5/6	1.00	1.00
W	White	1.00	1.00	1.00	—	0.00	1.00
R_{75}	75% Red	0.75	0.00	0.00	0	1.00	0.75
R_{50}	50% Red	0.50	0.00	0.00	0	1.00	0.50
R_{25}	25% Red	0.25	0.00	0.00	0	1.00	0.25
P	Pink	1.00	0.50	0.50	0	0.5	1.00

Primer

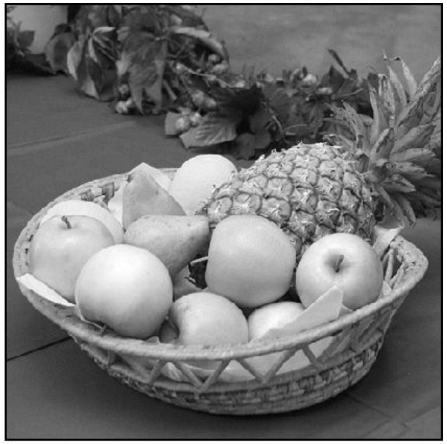




H_{HSV}



S_{HSV}



V_{HSV}

Pretvorba iz RGB v HSV

$$C_{\text{high}} = \max(R, G, B) \quad C_{\text{low}} = \min(R, G, B) \quad C_{\text{rng}} = C_{\text{high}} - C_{\text{low}}$$

$$S_{\text{HSV}} = \begin{cases} \frac{C_{\text{rng}}}{C_{\text{high}}} & \text{for } C_{\text{high}} > 0 \\ 0 & \text{otherwise} \end{cases}$$

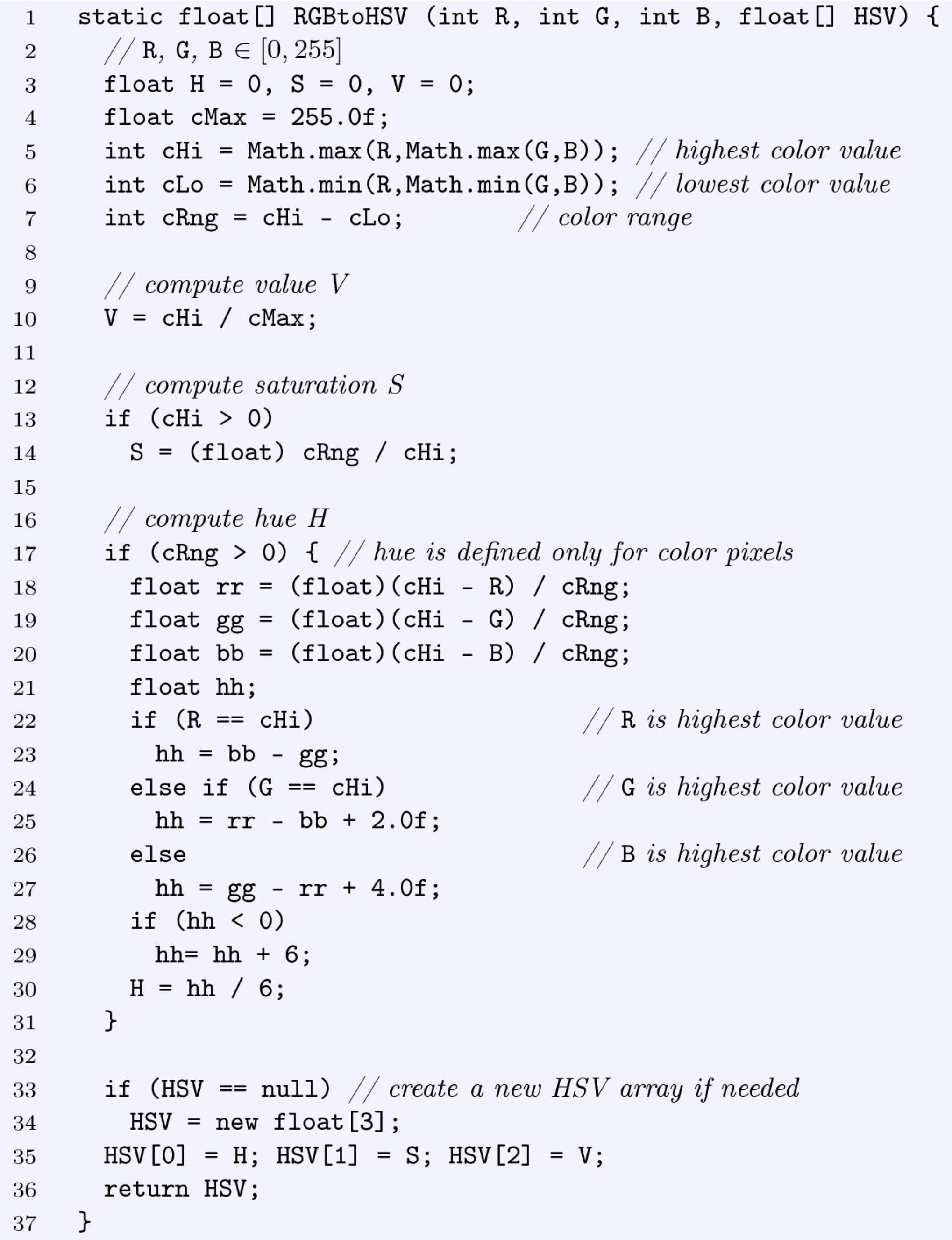
$$V_{\text{HSV}} = \frac{C_{\text{high}}}{C_{\text{max}}} \longleftarrow 255$$

$$R' = \frac{C_{\text{high}} - R}{C_{\text{rng}}} \qquad G' = \frac{C_{\text{high}} - G}{C_{\text{rng}}} \qquad B' = \frac{C_{\text{high}} - B}{C_{\text{rng}}}$$

$$H' = \begin{cases} B' - G' & \text{if } R = C_{\text{high}} \\ R' - B' + 2 & \text{if } G = C_{\text{high}} \\ G' - R' + 4 & \text{if } B = C_{\text{high}} \end{cases}$$

$$H_{\text{HSV}} = \frac{1}{6} \cdot \begin{cases} (H' + 6) & \text{for } H' < 0 \\ H' & \text{otherwise} \end{cases}$$

Algoritem



```
static float[] RGBtoHSV (int R, int G, int B, float[] HSV) {
  // R, G, B ∈ [0, 255]
  float H = 0, S = 0, V = 0;
  float cMax = 255.0f;
  int cHi = Math.max(R,Math.max(G,B)); // highest color value
  int cLo = Math.min(R,Math.min(G,B)); // lowest color value
  int cRng = cHi - cLo;         // color range

  // compute value V
  V = cHi / cMax;

  // compute saturation S
  if (cHi > 0)
    S = (float) cRng / cHi;

  // compute hue H
  if (cRng > 0) { // hue is defined only for color pixels
    float rr = (float)(cHi - R) / cRng;
    float gg = (float)(cHi - G) / cRng;
    float bb = (float)(cHi - B) / cRng;
    float hh;
    if (R == cHi)                       // R is highest color value
      hh = bb - gg;
    else if (G == cHi)                  // G is highest color value
      hh = rr - bb + 2.0f;
    else                                // B is highest color value
      hh = gg - rr + 4.0f;
    if (hh < 0)
      hh= hh + 6;
    H = hh / 6;
  }

  if (HSV == null) // create a new HSV array if needed
    HSV = new float[3];
  HSV[0] = H; HSV[1] = S; HSV[2] = V;
  return HSV;
}
```

Pretvorba iz HSV v RGB

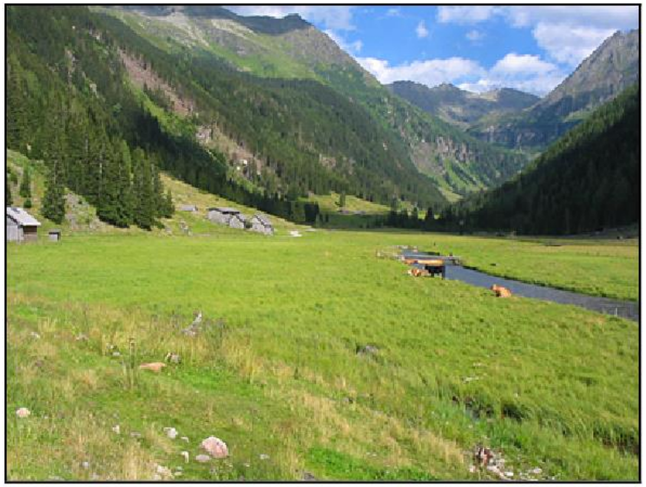
$$H' = (6 \cdot H_{\mathrm{HSV}}) \bmod 6$$

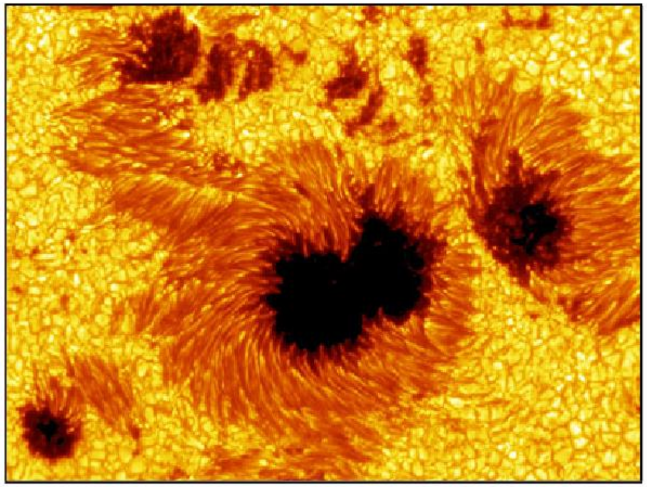
$$\begin{aligned} c_1 &= \lfloor H' \rfloor & x &= (1 - S_{\mathrm{HSV}}) \cdot v \\ c_2 &= H' - c_1 & y &= (1 - (S_{\mathrm{HSV}} \cdot c_2)) \cdot V_{\mathrm{HSV}} \\ & & z &= (1 - (S_{\mathrm{HSV}} \cdot (1 - c_2))) \cdot V_{\mathrm{HSV}} \end{aligned}$$

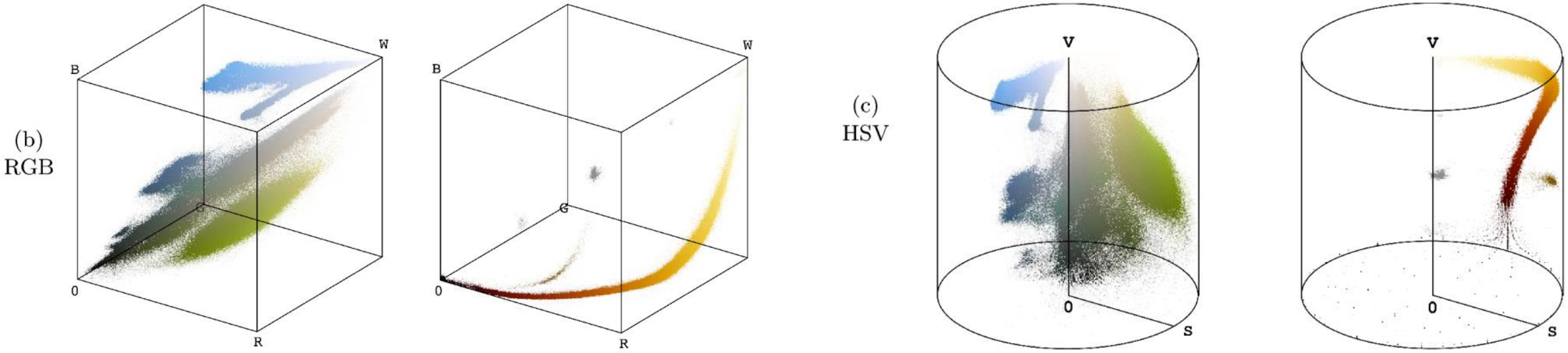
$$(R', G', B') = \begin{cases} (v, z, x) & \text{if } \; c_1 = 0 \\ (y, v, x) & \text{if } \; c_1 = 1 \\ (x, v, z) & \text{if } \; c_1 = 2 \\ (x, y, v) & \text{if } \; c_1 = 3 \\ (z, x, v) & \text{if } \; c_1 = 4 \\ (v, x, y) & \text{if } \; c_1 = 5. \end{cases}$$

$$\begin{aligned} R &= \min\bigl(\mathrm{round}(N \cdot R'), N - 1\bigr) \qquad 256 \\ G &= \min\bigl(\mathrm{round}(N \cdot G'), N - 1\bigr) \\ B &= \min\bigl(\mathrm{round}(N \cdot B'), N - 1\bigr) \end{aligned}$$

Primer





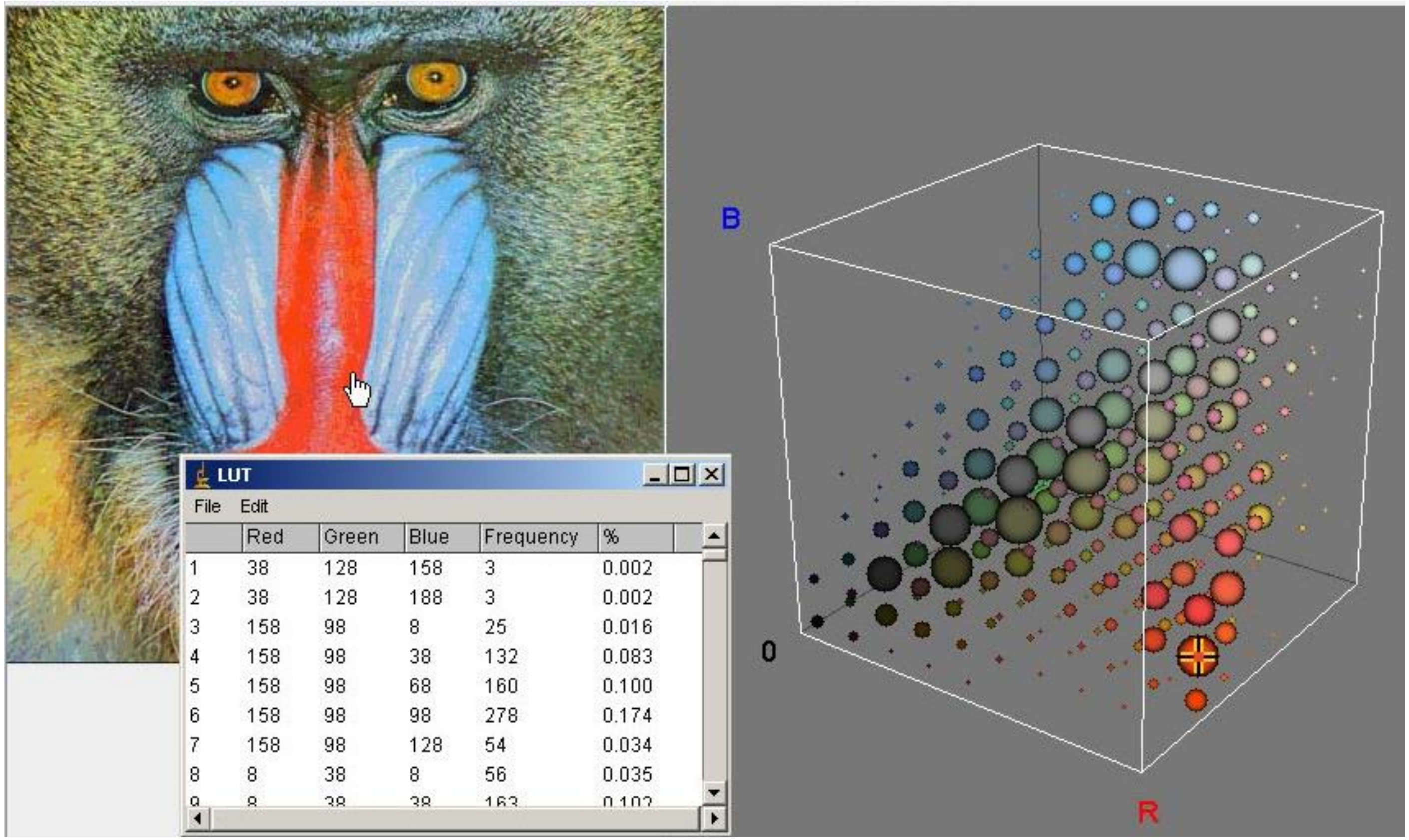


Drugi barvni prostori

- HLS
- TV barvni prostori
  - YUV
  - YIQ
  - YCbCr
- Barvni prostori za tisk
  - CMY
  - CMYK
- Kolorimetrični barvni prostori
  - CIE XYZ
  - CIE YUV, YU‘V‘, L*u*v, YCbCr
  - CIE L*a*b*
  - sRGB

3D barvni histogrami

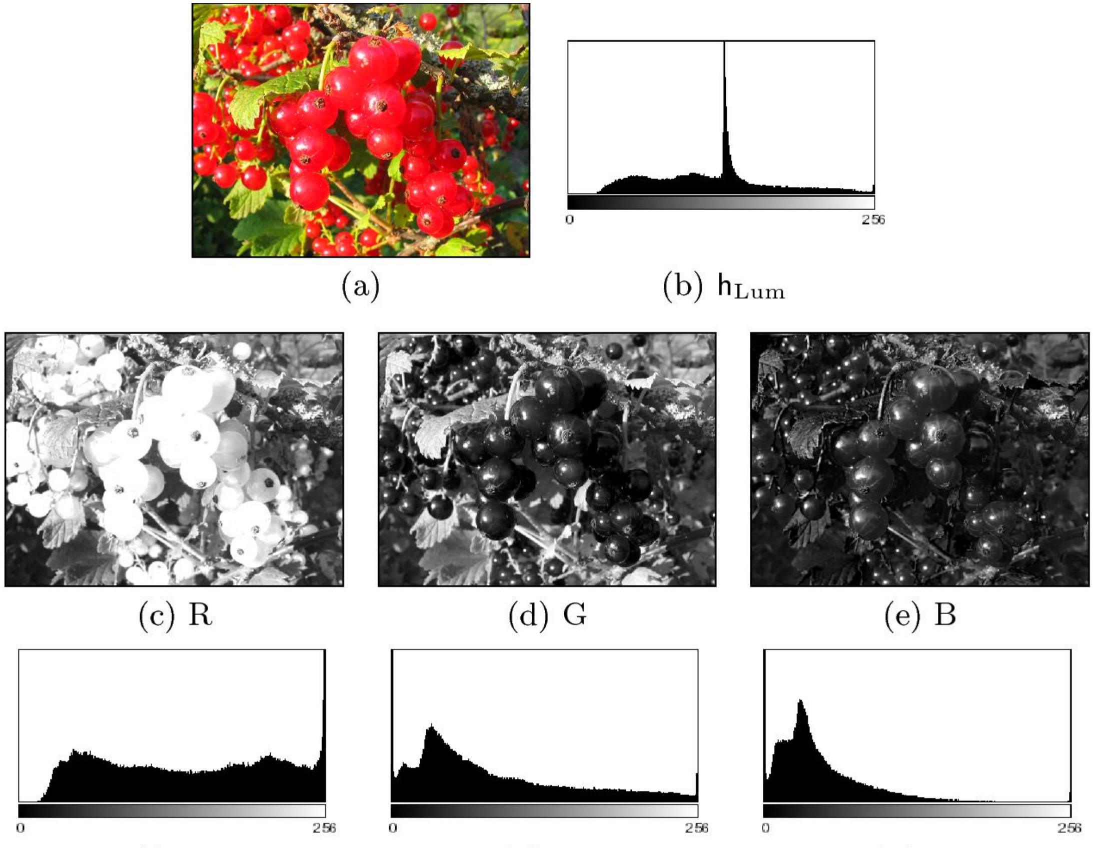
- 3 komponente -> 3D histogram
  - Zelo prostorsko zahtevni in „redki"



	Red	Green	Blue	Frequency	%
1	38	128	158	3	0.002
2	38	128	188	3	0.002
3	158	98	8	25	0.016
4	158	98	38	132	0.083
5	158	98	68	160	0.100
6	158	98	98	278	0.174
7	158	98	128	54	0.034
8	8	38	8	56	0.035
9	8	38	38	163	0.102

1D barvni histogrami

- 1 D histogram posameznih komponent
  - Ne zajamjo odvisnosti med posameznimi barvnimi komponentami



(a)

(b) h_{Lum}

(c) R

(d) G

(e) B

(f) h_{R}

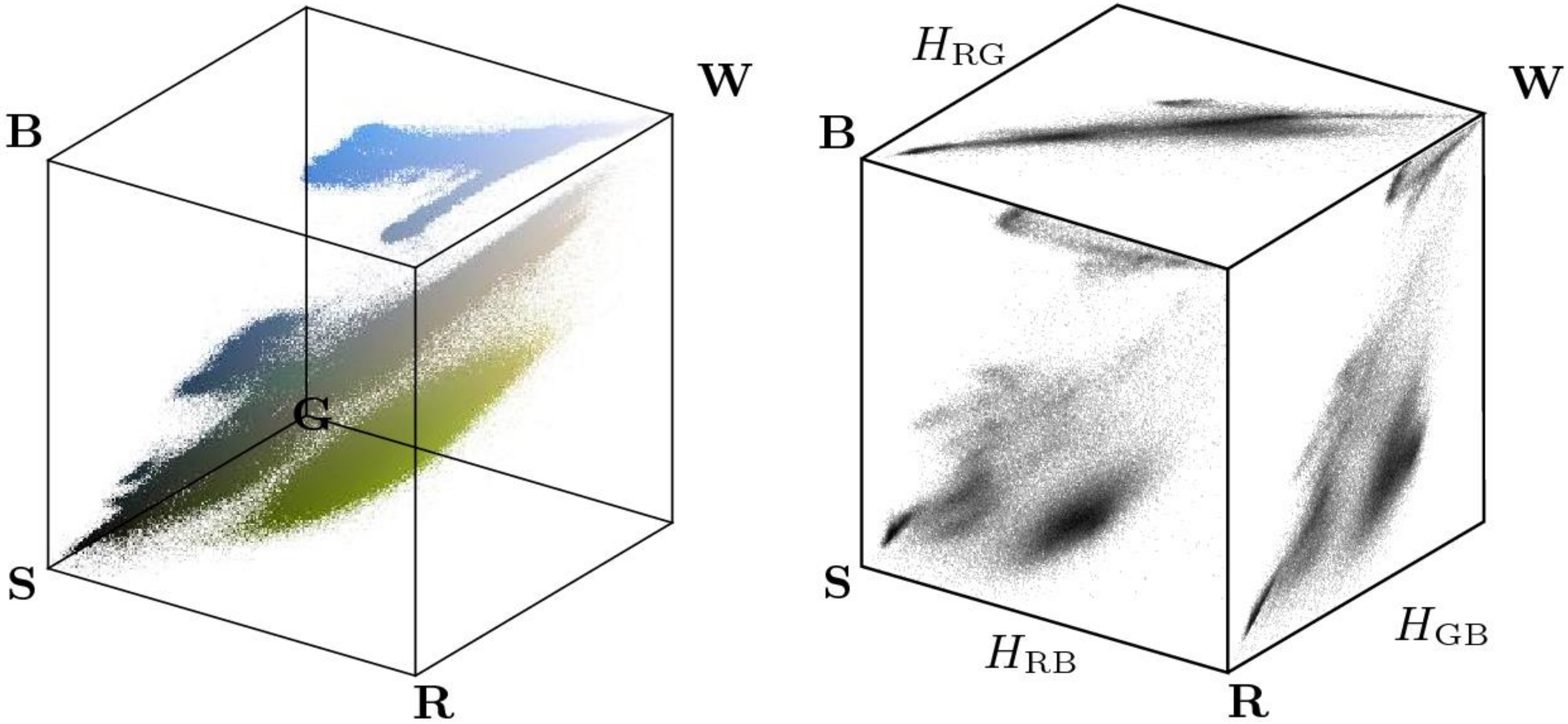
(g) h_{G}

(h) h_{B}

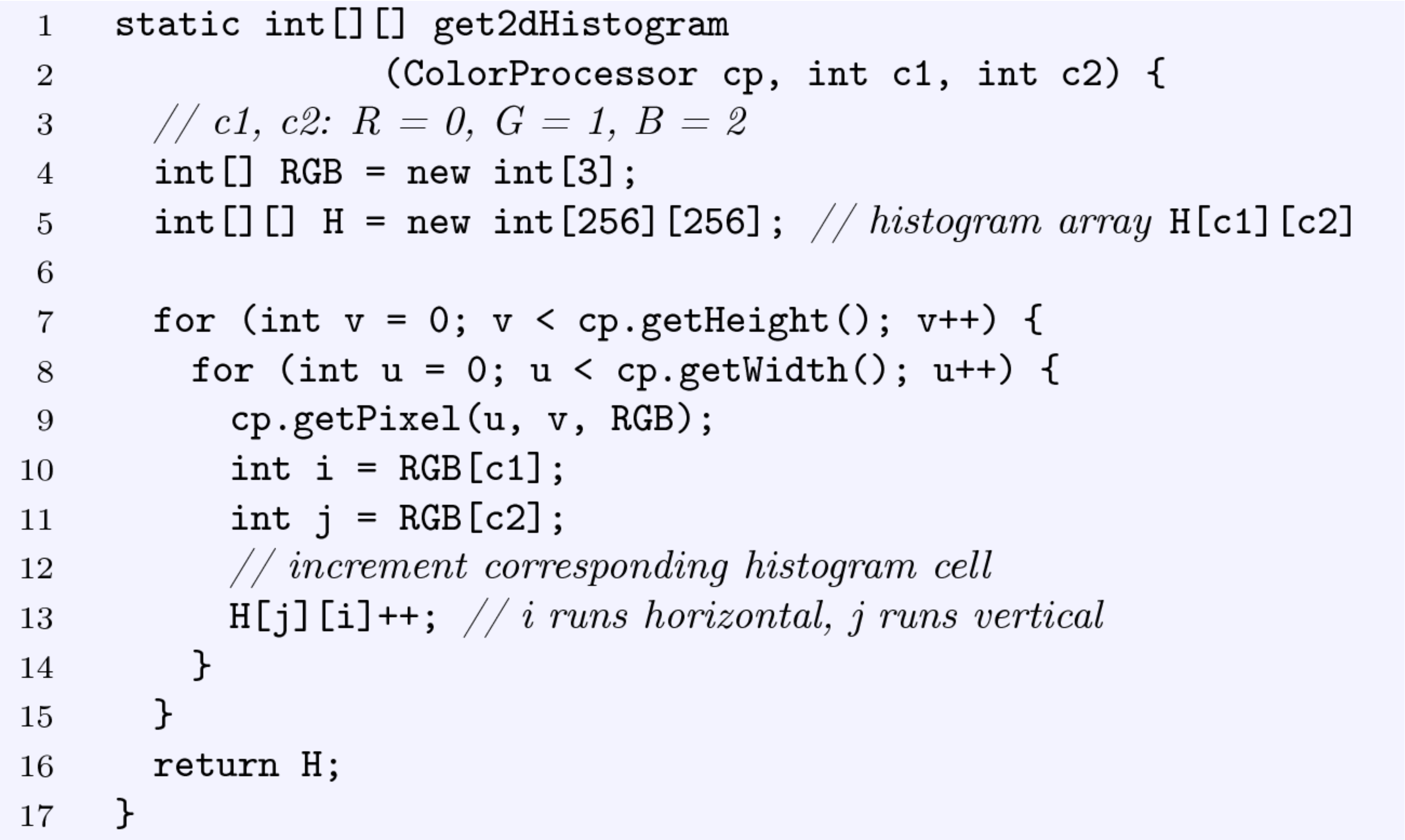
2D barvni histogrami

- Izračunamo pare 2D histogramov
    - Zajamejo vsaj delno odvisnost med barvnimi komponentami

$$
\begin{aligned}
H_{\mathrm{RG}}(r,g) &\leftarrow \text{number of pixels with } I_{\mathrm{RGB}}(u,v)=(r,g,*)\\
H_{\mathrm{RB}}(r,b) &\leftarrow \text{number of pixels with } I_{\mathrm{RGB}}(u,v)=(r,*,b)\\
H_{\mathrm{GB}}(g,b) &\leftarrow \text{number of pixels with } I_{\mathrm{RGB}}(u,v)=(*,g,b)
\end{aligned}
$$



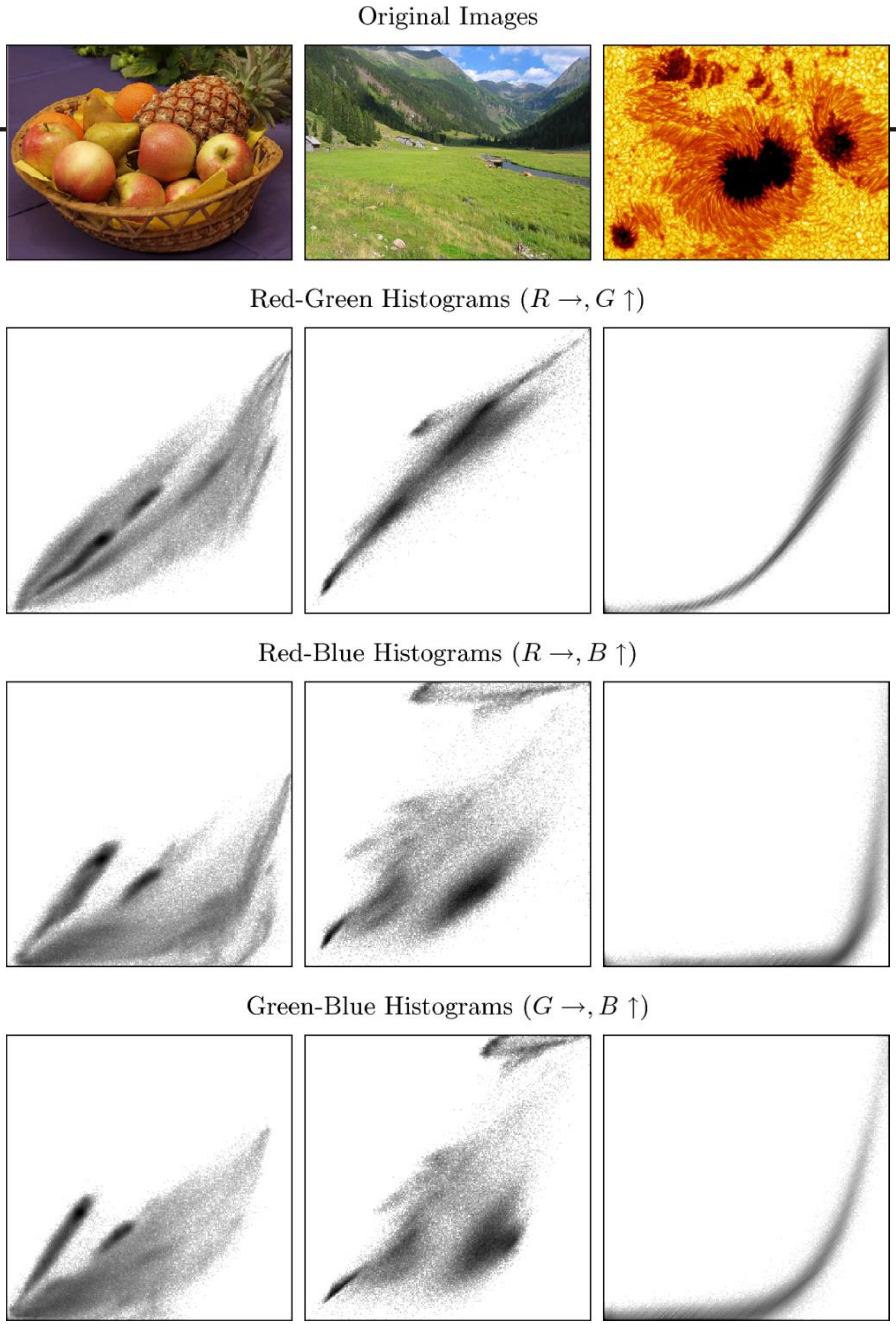
Algoritem



```
static int[][] get2dHistogram
                 (ColorProcessor cp, int c1, int c2) {
  // c1, c2: R = 0, G = 1, B = 2
  int[] RGB = new int[3];
  int[][] H = new int[256][256]; // histogram array H[c1][c2]

  for (int v = 0; v < cp.getHeight(); v++) {
    for (int u = 0; u < cp.getWidth(); u++) {
      cp.getPixel(u, v, RGB);
      int i = RGB[c1];
      int j = RGB[c2];
      // increment corresponding histogram cell
      H[j][i]++; // i runs horizontal, j runs vertical
    }
  }
  return H;
}
```

Primeri



Original Images

Red-Green Histograms $(R \rightarrow, G \uparrow)$

Red-Blue Histograms $(R \rightarrow, B \uparrow)$

Green-Blue Histograms $(G \rightarrow, B \uparrow)$