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THE METHOD OF DETERMINATION BOUNDARIES IN UNIFORM COLOR SPACE OF COLOR GAMUT TRANSMITTED AND REPRODUCED BY TV AND OTHER IMAGING SYSTEMS

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МЕТОД ПОСТРОЕНИЯ ГРАНИЦ ОБЛАСТИ ЦВЕТОВ В РАВНОКОНТРАСТНОМ ЦВЕТОВОМ ПРОСТРАНСТВЕ, ПЕРЕДАВАЕМЫХ И ВОСПРОИЗВОДИМЫХ ТВ СИСТЕМАМИ

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Abstract. *A method of definition color gamut, transmitted and reproduced by TV systems and by other video applications, built on the basis of use of the additive colorimetry.*

Аннотация. *Представлен метод построения области цветов, передаваемых и воспроизводимых ТВ системами и другими видеоприложениями, построенными на основе использования аддитивной колориметрии.*

Color gamut that can be transmitted by TV system, is one of the main indicators of the level of perfection of the system, because it characterizes the ability of a system to transmit colors of the real world. Therefore, the interest in this feature will always appear when a solution that may affect color gamut is made.

Hence, it would be desirable to have an algorithm to determine color gamut which may be transmitted available to specialists.

It should be borne in mind that the signal space of red, green and blue primary colors RGB, XYZ and CIE-31 colorimetric space, the most widely used for color presentation are not Euclidean in respect to human color perception. Equal distances between the points of color in these spaces do not meet the equal color differences.

Therefore, in order to correctly quantify judges on the colour gamut size that can be transmitted by the television system, it is needed to use a color presentation points in uniform color space in which equal distances between the points of colors correspond to equal color differences across all the color space. Such representation may be implemented when used advanced models of color perception, among which can be regarded as the most perfect model CIECAM02 [1, 2], with its further supplement as a model CAM02-USC, proposed by Luo et al. [3].

For representation of the transmitted color gamut in uniform color space it is needed to select the following data describing the properties of adaptive model of color appearance:

– adapting luminance L_A cd/m^2, which is usually taken equal $L_A = 0,2L_{DW}$, where L_{DW} – the luminance of the reference white of the image;

– environmental conditions (average, dim or dark , which are determined by the relation of luminance of the surrounding background L_{SW}, the color of which is taken relevant to the reference white and luminance L_{DW} of white of reproduced image;

– select the model of the proposed in [3], the corresponding small (CAM02–SCD), large (CAM02–LCD) color difference and the combination of small and large (CAM02–UCS) designed for universal case. For the broadcast television and related applications the model CAM02–UCS can be considered as the preferred choice.

Building of transmitted color gamut area in the uniform color space can be composed of the following steps:

– the specification of the chromaticity coordinates of primary colors and white reference of the system, as well as the level of relative lightness of Y, for which the transmitted color gamut boundary is being defined;

– the specification of uniform color space model parameters: adapting luminance L_A, environmental conditions, selection of model variant CAM02–UCS;

– determination primary color luminance factors L_R, L_G, L_B;

– building of the boundary lines equations in the plane of the chromaticity coordinates r, g, b of the R, G, B signals space, which are the boundaries of transmitted color gamut for a given relative luminance Y;

– transformation of the boundary lines equations in the space of the R, G, B signals space to the equations of boundary lines in the space X, Y, Z as a function of the chromaticity coordinates x, y, z for color gamut area defined by the relationship of the relative brightness Y and primary color luminance factors L_R, L_G, L_B;

– determination of boundaries of the transmitted color gamut, which is the association of sides of a triangle cross section of color and boundary line for a given level of relative brightness as a function of chromaticity coordinates ;

– determination of boundaries of color gamut in uniform space CAM02-UCS using models CIECAM02 and CAM02-USC.

Below the steps of this transformations are described.

Boundary lines of the transmitted color in chromaticity coordinate system r,g,b is defined in accordance with equations [4, 5]:

$$b \le \frac{(L_R - L_G)\cdot r + L_G}{Y + (L_G - L_B)}; \quad r \le \frac{(L_B - L_G)\cdot b + L_G}{Y + (L_G - L_B)}; \quad g \le \frac{(L_R - L_B)\cdot r + L_B}{Y + (L_B - L_G)}.$$

Transition into the space X, Y, Z is implemented for Y given by transition coordinates of the points of boundary lines represented in the coordinates r, g, b into the representation in the coordinates x, y, z in accordance with SMPTE RP.177 [6], which is the following.

The starting point is the relative luminance Y and the chromaticity coordinates r, g, b of specified color.

Color primaries chromaticity coordinates matrix and reference white chromaticity coordinates vector are specified:

$$\mathbf{P} = \begin{bmatrix} x_R & x_G & x_B \\ y_R & y_G & y_B \\ z_R & z_G & z_B \end{bmatrix}; \qquad \overline{\mathbf{w}} = \begin{bmatrix} x_W / y_W \\ 1 \\ z_W / y_W \end{bmatrix}$$

Define the transformation matrix:

$$\mathbf{NPM} = \begin{bmatrix} X_R & X_G & X_B \\ Y_R & Y_G & Y_B \\ Z_R & Z_G & Z_B \end{bmatrix} = \mathbf{P} \cdot \mathrm{diag}\left(\mathbf{P}^{-1} \cdot \overline{\mathbf{w}}\right),$$

elements of which are the absolute coordinates of the primary colors.

Realize a transition into the X, Y, Z space:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \mathbf{NPM}^{-1} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}.$$

Here:

$$R = Y\frac{r}{L_R r + L_G g + L_B b}; \quad G = Y\frac{g}{L_R r + L_G g + L_B b}; \quad B = Y\frac{b}{L_R r + L_G g + L_B b}$$

– levels of color primaries signals, normalized to the unit level;

$$L_R = Y_R; \quad L_G = Y_G; \quad L_B = Y_B$$

- primary color luminance factors L_R, L_G, L_B (2nd row of NPM).

Determine the chromaticity coordinates in X, Y, Z space:

$$x = \frac{X}{X+Y+Z}; \quad y = \frac{Y}{X+Y+Z}; \quad z = \frac{Z}{X+Y+Z}$$

The boundary lines that characterize the limitation of the transmitted color of the vertices R, G, B of the triangle of HDTV system primary colors for the relative luminance levels that are equal $Y = 0,01; 0,1; 0,2; ... 0,8; 0,9$, are shown in Figures 1–3.

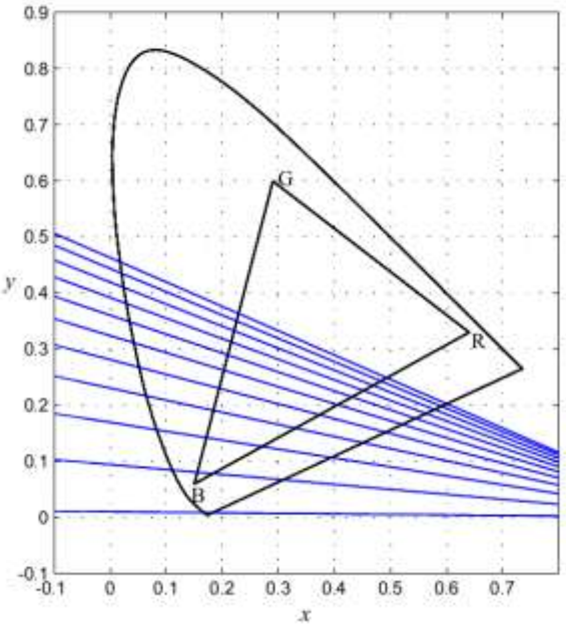

Figure 1 – Boundary lines, limiting blue area

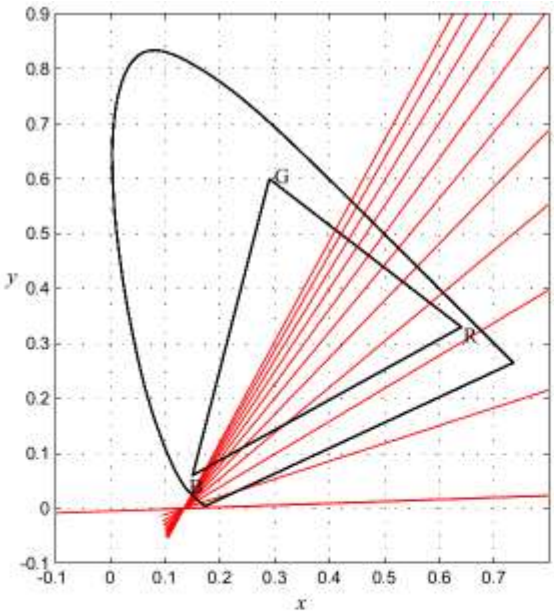

Figure 2 – Boundary lines, limiting red area

Fig. 4-6 show examples of building transmitted color gamut boundaries, on the one hand, the principle of building transmitted color gamut boundaries, on the other hand, the difficulties of building color gamut area formalization.

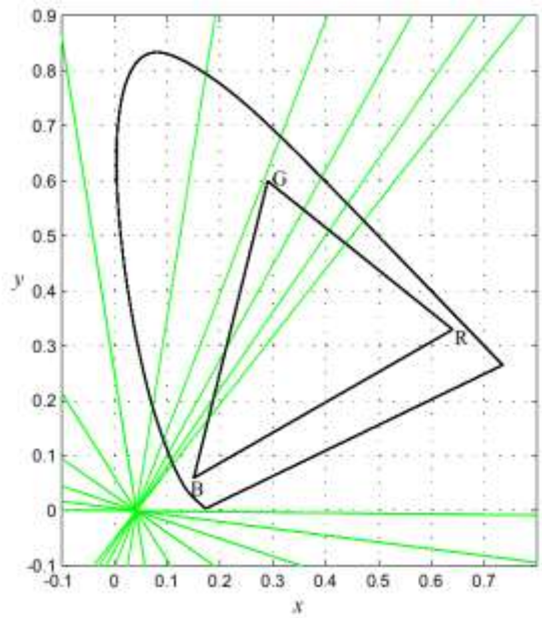

Figure 3 – Boundary lines, limiting green area

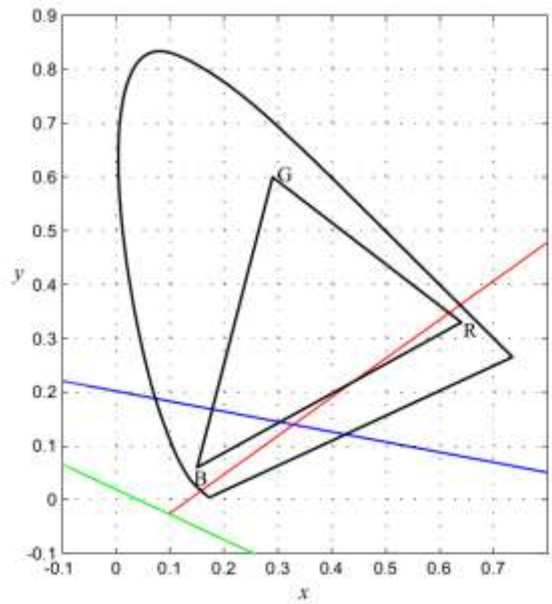

Figure 4 – Boundary lines, limiting red, green and blue areas for the relative luminance of Y = 0.25

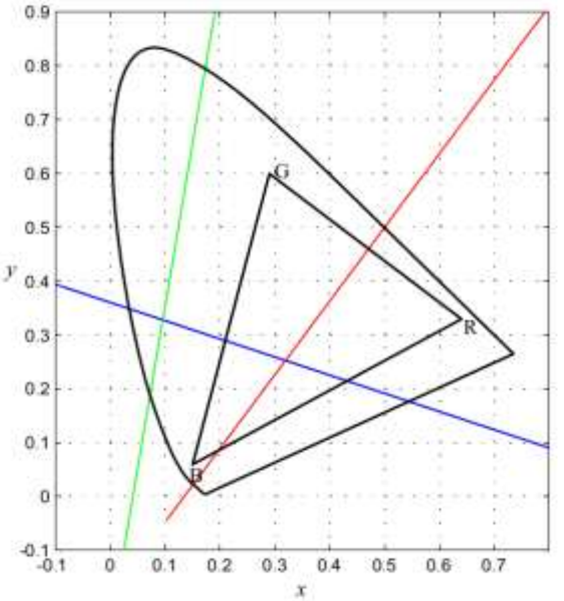

Figure 5 – Boundary lines, limiting red, green and blue areas for the relative luminance of Y = 0.6

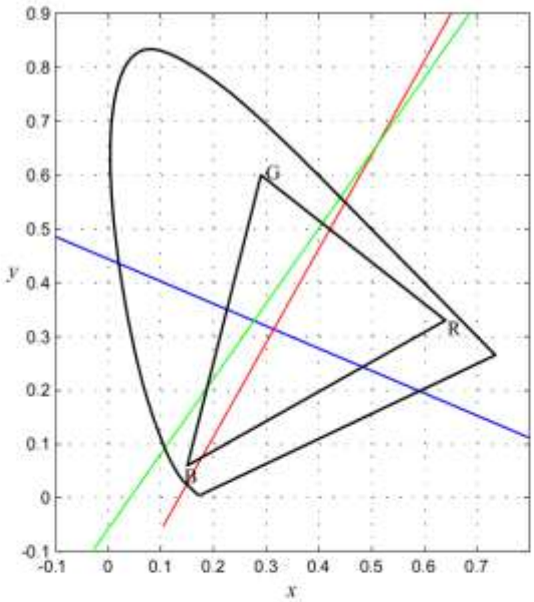

Figure 6 – Boundary lines, limiting red, green and blue areas for the relative luminance of Y = 0.9

The definition of the transmitted color gamut for a given relative luminance Y may be made for the two cases when the triangle is inside the chromaticity diagram or covers it. Both cases in terms of defining the boundaries of this area are equivalent.

Once defined boundary lines, the task of determining the area of the transmitted color gamut is to build color gamut area boundary as the curve, unifying plot the chromaticity diagram boundary or of primaries triangle boundary, including the reference white point and the boundary line plot. This can be implemented in various computing environments. For example, in MATLAB the border area can be presented and displayed graphically as the boundary of the polygon whose vertices are the points of monochromatic colors and the points of the boundary line. Listing of programs showed in the Table 1.

In Figures 7-9 the steps of building the boundary of transmitted color gamut area as as the sequential implementation of restrictions imposed by R, G, B vertices are presented.

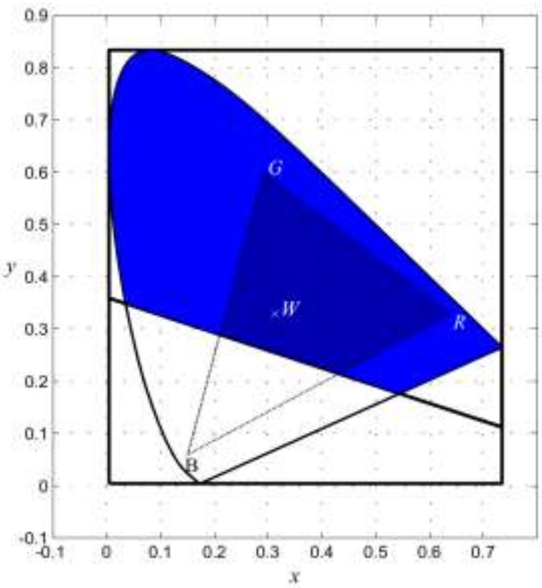

Figure 7 – Blue area limitation for Y = 0.6

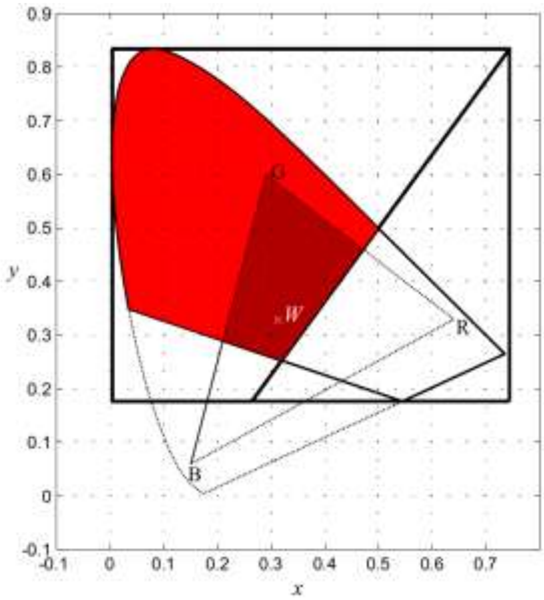

Figure 8 – Blue area limitation for Y = 0.6

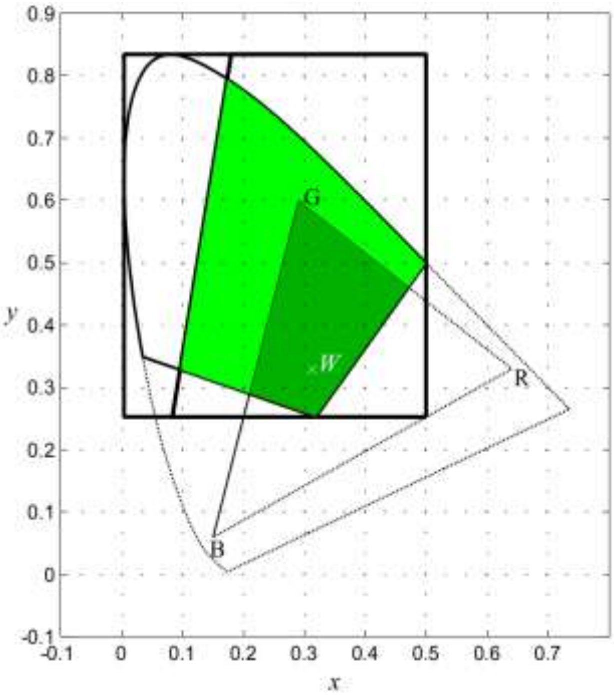

Figure 9 – Green area limitation for Y = 0.6

Table 1 – Listing of program for determinate boundaries

```
clc; clear all; close all;

xr=0.6400; yr=0.3300; zr=0.0300;
xg=0.3000; yg=0.6000; zg=0.1000;
xb=0.1500; yb=0.0600; zb=0.7900;
xw=0.3127; yw=0.3290; zw=0.3583;

xyz=[xw;yw;zw];
P=[xr,xg,xb;yr,yg,yb;zr,zg,zb];
W=[xw;yw;zw];

Smin=0; Smax=1;
Y=0.5;

nY=length(Y);

for i=1:nY
    figure
    hold all; grid on;

            [L,NPM]=CLR_Param(P,W);

                function [L,NPM] = CLR_Param(P,W)

                w=[W(1)/W(2);1;W(3)/W(2)];

                xR=P(1,1);xG=P(1,2);xB=P(1,3);
                yR=P(2,1);yG=P(2,2);yB=P(2,3);
                zR=P(3,1);zG=P(3,2);zB=P(3,3);

                M=[xR/yR, xG/yG, xB/yB;
                      1,      1,      1;
                   zR/yR, zG/yG, zB/yB];
```

```
    L=M\w;
    NPM=P*diag((P\w));

[X_lambda,Y_lambda] = ChromaLocus; % Value of CIE chromaticities
diagram
LR=L(1);LG=L(2);LB=L(3);
x0=W(1);y0=W(2);


b=-0.8:0.2:1.8; mb=length(b);
r=zeros(1,mb); g=zeros(1,mb);
xBmin=zeros(1,mb); yBmin=zeros(1,mb); zBmin=zeros(1,mb);

c0_Bmin=-Smin*LG/(Smin*(LR-LG));
c1_Bmin=(Smin*(LG-LB)+Y)/(Smin*(LR-LG));

for i=1:mb;
  r(i)=c0_Bmin+c1_Bmin*b(i); g(i)=1-r(i)-b(i);
  RGB=[r(i); g(i); b(i)]; [xyz]=rgb_xyz(RGB,P,W);
  xBmin(i)=xyz(1); yBmin(i)=xyz(2); zBmin(i)=xyz(3);
end;

a1_Bmin=(yBmin(mb)-yBmin(1))/(xBmin(mb)-xBmin(1));
a0_Bmin=yBmin(1)-xBmin(1)*a1_Bmin;
a0=a0_Bmin; a1=a1_Bmin;

[BX_CS, BY_CS] = LP_CS(X_lambda,Y_lambda,x0,y0,a0,a1);
     function [X_CS, Y_CS] = LP_CS(X,Y,x0,y0,a0,a1)

    v=zeros(1,3);w=zeros(1,3);
    x_S =zeros(1,4); y_S =zeros(1,4);
    x_S1=zeros(1,4); y_S1=zeros(1,4);
    x_S2=zeros(1,4); y_S2=zeros(1,4);

    X_min = min(X); X_max = max(X); Y_min = min(Y); Y_max =
    max(Y);

    if abs(a1)<=1;

       x1=X_min; x2=X_max;

       v(1)=Y_min;  v(2)=a0+a1*X_min;  v(3)=a0+a1*X_max;
       w(1)=Y_max;  w(2)=v(2);         w(3)=v(3);

       y1=min(v); y2=max(w);

       x_S1(1)=x1; y_S1(1)=a0+a1*x1;
       x_S1(2)=x1; y_S1(2)=y2;
       x_S1(3)=x2; y_S1(3)=y2;
       x_S1(4)=x2; y_S1(4)=a0+a1*x2;

       x_S2(1)=x1; y_S2(1)=y1;
       x_S2(2)=x1; y_S2(2)=a0+a1*x1;
       x_S2(3)=x2; y_S2(3)=a0+a1*x2;
       x_S2(4)=x2; y_S2(4)=y1;
```

```
      else

          y1=Y_min;
          y2=Y_max;

      if abs(a1)<=10^(-8); a1=sign(a1)*10^(-8); end;

          b0=-a0/a1;
          b1=1/a1;

          v(1)=X_min; v(2)=b0+b1*Y_min; v(3)=b0+b1*Y_max;
          w(1)=X_max; w(2)=v(2); w(3)=v(3);

          x1=min(v);  x2=max(w);

          x_S1(1)=b0+b1*y1; y_S1(1)=y1;
          x_S1(2)=x1;       y_S1(2)=y1;
          x_S1(3)=x1;       y_S1(3)=y2;
          x_S1(4)=b0+b1*y2; y_S1(4)=y2;

          x_S2(1)=x2;       y_S2(1)=y1;
          x_S2(2)=b0+b1*y1; y_S2(2)=y1;
          x_S2(3)=b0+b1*y2; y_S2(3)=y2;
          x_S2(4)=x2;       y_S2(4)=y2;

      end;

      [IN1 ON1]=inpolygon(x0,y0,x_S1,y_S1);
      [IN2 ON2]=inpolygon(x0,y0,x_S2,y_S2);

      if IN1==1 && IN2==0
        x_S=x_S1; y_S=y_S1;
      elseif IN1==0 && IN2==1
        x_S=x_S2; y_S=y_S2;
      elseif ON1==1 || ON2==1
          for k=1:1:4;
              x_S(k)=x0; y_S(k)=y0;
          end;
      end;

      [X_CS, Y_CS]=polybool('intersection',x_S,y_S,X,Y);

b=-0.83:0.1:1.27; mr=length(b);
r=zeros(1,mr); g=zeros(1,mr);

c0_Rmin=-LG*Smin/(Smin*(LR-LG)-Y);
c1_Rmin=Smin*(LG-LB)/(Smin*(LR-LG)-Y);
xRmin=zeros(1,mr); yRmin=zeros(1,mr); zRmin=zeros(1,mr);

for i=1:mr;
    r(i)=c0_Rmin+c1_Rmin*b(i);  g(i)=1-r(i)-b(i);
    RGB=[r(i); g(i); b(i)]; [xyz]=rgb_xyz(RGB,P,W);
    xRmin(i)=xyz(1);yRmin(i)=xyz(2);zRmin(i)=xyz(3);
end;

a1_Rmin=(yRmin(mr)-yRmin(1))/(xRmin(mr)-xRmin(1));
```

```
        a0_Rmin=yRmin(1)-xRmin(1)*a1_Rmin;
        a0=a0_Rmin;a1=a1_Rmin;

        [XR_CS, YR_CS] = LP_CS(BX_CS,BY_CS,x0,y0,a0,a1);
             function [X_CS, Y_CS] = LP_CS(X,Y,x0,y0,a0,a1)
            (…) % listing the function see above
        b=-0.83:0.1:1.2; mg=length(b);
        r=zeros(1,mg); g=zeros(1,mg);
        xGmin=zeros(1,mg); yGmin=zeros(1,mg); zGmin=zeros(1,mg);

        c0_Gmin=(Y-Smin*LG)/(Smin*(LR-LG)+Y);
        c1_Gmin=(Smin*(LG-LB)-Y)/(Smin*(LR-LG)+Y);

        for i=1:mg;
           r(i)=c0_Gmin+c1_Gmin*b(i);  g(i)=1-r(i)-b(i);
           RGB=[r(i); g(i); b(i)]; [xyz]=rgb_xyz(RGB,P,W);
           xGmin(i)=xyz(1);yGmin(i)=xyz(2);zGmin(i)=xyz(3);
        end;

        a1_Gmin=(yGmin(mg)-yGmin(1))/(xGmin(mg)-xGmin(1));
        a0_Gmin=yGmin(1)-xGmin(1)*a1_Gmin;
        a0=a0_Gmin; a1=a1_Gmin;

        [X_CS,Y_CS] = LP_CS(XR_CS,YR_CS,x0,y0,a0,a1);
            function [X_CS, Y_CS] = LP_CS(X,Y,x0,y0,a0,a1)
            (…)% listing the function see above

    axis([-0.1 0.8 -0.1 0.9]);

    RGB=zeros(3,1);

    plot(X_lambda,Y_lambda,'-k','LineWidth',0.5);
    plot(X_CS,Y_CS,'-b','LineWidth',2)

    xlabel('X','fontsize',14,'fontname','TimesNewRoman');
    ylabel('Y','Rotation',0,'fontsize',14,'fontname','TimesNewRoman');

    text(xtr(3), ytr(3)-0.03,'R','HorizontalAlignment','left');
    text(xtr(1)+0.02, ytr(1)-0.02,'B','HorizontalAlignment','left');
    text(xtr(5)+0.02, ytr(5)+0.02,'G','HorizontalAlignment','left');
end;
LA=[50];
CAM='CAM02_UCS';
VC='average';
 [J1,aM1,bM1]=CS_border_RGB_CAM02_LL(Smin,Smax,P,W,Y,CAM,VC,LA);

     switch CAM
         case'CAM02_LCD'
             KL=0.77;c1=0.007;c2=0.0053; %#ok<NASGU>
         case'CAM02_SCD'
             KL=1.24;c1=0.007;c2=0.0363; %#ok<NASGU>
         case'CAM02_UCS'
             KL=1;c1=0.007;c2=0.0228; %#ok<NASGU>
     end

        [J,M,h]=CS_border_RGB_CIECAM02(Smin,Smax,P,W,Y,VC,LA);
```

```
function [J,M,h]=CS_border_RGB_CIECAM02(Smin,Smax,P,W,Y,VC,LA)

 [X_CS,Y_CS]=CS_border_RGB(Smin,Smax,P,W,Y);
    function [X_CS,Y_CS]=CS_border_RGB(Smin,Smax,P,W,Y)

    [X_CS_min,Y_CS_min]=CS_border_RGBmin(Smin,P,W,Y);
    [X_CS_max,Y_CS_max]=CS_border_RGBmax(Smax,P,W,Y);

    [X_CS,Y_CS] =
    polybool('intersection',X_CS_min,Y_CS_min,X_CS_max,Y_CS_m
    ax);

N=length(X_CS);
x =zeros(1,N); y =zeros(1,N); z =zeros(1,N); %#ok<*NASGU>

YY=100*Y;
xW=W(1);     yW=W(2);  zW=W(3);
YW=100; XW=xW*YW/yW;    ZW=zW*YW/yW;

x=X_CS;
y=Y_CS;
z=1-x-y;
    J=zeros(1,N);
for k=1:1:N;
   XX=x(k)*YY/y(k); ZZ=z(k)*YY/y(k);
   [J(k),M(k),h(k)]=CIECAM02(XX,YY,ZZ,XW,YW,ZW,VC,LA);
    function [J,M,h]=CIECAM02(X,Y,Z,XW,YW,ZW,VC,LA)
     %
    MCAT02=[0.7328 0.4296 -0.1624;
           -0.7036 1.6975  0.0061;
            0.0030 0.0136  0.9834];

    XYZ=[X;Y;Z];
    RGB=MCAT02*XYZ;
    R=RGB(1); G=RGB(2); B=RGB(3);

    RGBw=MCAT02*[XW;YW;ZW];
    Rw=RGBw(1); Gw=RGBw(2); Bw=RGBw(3);

    switch VC
       case 'average'
          c=0.69;  Nc=1.0; F=1.0;
       case 'dim'
          c=0.59;  Nc=0.9; F=0.9;
       case 'dark'
          c=0.525; Nc=0.8; F=0.8;
    end

    D=F*(1-((1/3.6)*(exp((-(LA+42))/92))));

    RC=R*((YW*(D/Rw))+(1-D));
    GC=G*((YW*(D/Gw))+(1-D));
    BC=B*((YW*(D/Bw))+(1-D));

    RCW=Rw*((YW*(D/Rw))+(1-D));
    GCW=Gw*((YW*(D/Gw))+(1-D));
```

```
BCW=Bw*((YW*(D/Bw))+(1-D));

k=1/(5*LA+1);
FL=(0.2*(k^4))*(5*LA)+0.1*(1-k^4)^2*(5*LA)^(1/3);
Yb=YW/5;
n=Yb/YW;
Nbb=0.725*(1/n)^0.2;
Ncb=Nbb;
z=1.48+(n)^0.5;

MHPE=  [0.38971 0.68898 -0.07868;
       -0.22981 1.1834   0.04641;
        0       0        1      ];

MCAT02=[1.096124 -0.278869 0.182745;
        0.454369  0.473533 0.072098;
       -0.009628 -0.005698 1.015326];

RGBC=[RC;GC;BC];
RGB1=MHPE*MCAT02*RGBC;
RGBw1=MHPE*MCAT02*[RCW;GCW;BCW];

R1=RGB1(1);   G1=RGB1(2);   B1=RGB1(3);
Rw1=RGBw1(1); Gw1=RGBw1(2); Bw1=RGBw1(3);

sR=sign(R1);  sG=sign(G1);  sB=sign(B1);
sRw=sign(Rw1);sGw=sign(Gw1);sBw=sign(Bw1);

Ra=sR*((400*(((FL*sR*R1)/100))^0.42)/(27.13+(((FL*sR*R1)/
100)^0.42)))+0.1;
Ga=sG*((400*(((FL*sG*G1)/100))^0.42)/(27.13+(((FL*sG*G1)/
100)^0.42)))+0.1;
Ba=sB*((400*(((FL*sB*B1)/100))^0.42)/(27.13+(((FL*sB*B1)/
100)^0.42)))+0.1;

Raw=sRw*((400*(((FL*sRw*Rw1)/100))^0.42)/(27.13+(((FL*sRw
*Rw1)/100)^0.42)))+0.1;
Gaw=sGw*((400*(((FL*sGw*Gw1)/100))^0.42)/(27.13+(((FL*sGw
*Gw1)/100)^0.42)))+0.1;
Baw=sBw*((400*(((FL*sBw*Bw1)/100))^0.42)/(27.13+(((FL*sBw
*Bw1)/100)^0.42)))+0.1;

a=Ra-((12*Ga)/11)+Ba/11;
b=(1/9)*(Ra+Ga-2*Ba);
h1=atan(b/a);
hr=h1*(180/pi);

if     (a>0)&&(b>0); h=hr;
elseif (a<0)&&(b>0); h=hr+180;
elseif (a<0)&&(b<0); h=hr+180;
elseif (a>0)&&(b<0); h=hr+360;
end;

et=1/4*(cos((h*(pi/180))+2)+3.8);

A=(2*Ra+Ga+(1/20)*Ba-0.305)*Nbb;
```

```
                AW=(2*Raw+Gaw+(1/20)*Baw-0.305)*Nbb;

                J=100*((A/AW)^(c*z));

                t=((50000/13)*Nc*Ncb*et*(sqrt(a^2+b^2)))/(Ra+Ga+(21/20)*B
                a);

                C= t^0.9*sqrt(J/100)*(1.64-0.29^n)^0.73;
                M=C*FL^0.25;

                end;

      N=length(J);
      aM1=zeros(1,N);bM1=zeros(1,N);J1=zeros(1,N);

      for j=1:1:N;
        J1(j)=((1+100*c1)*J(j))/(1+c1*J(j));
        M1=(1/c2)*log(1+c2*M(j));
        h1=deg2rad(h(j));
        aM1(j)=M1*cos(h1);
        bM1(j)=M1*sin(h1);
      end;

format short g
```

The final stage of transformation is the transition from Y, x, y coordinates X, Y, Z space to the coordinates J', a'_M, b'_M of lightness and chroma of space CAM02-USC. An example of the color gamut transmitted is shown in Figure 10.

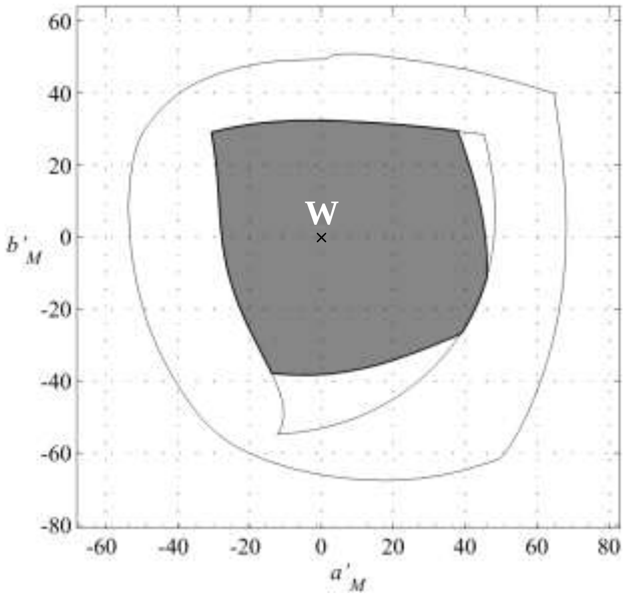

Figure 10 – Representation in CAM02-UCS coordinates for adapting luminance $L_A = 50$ cd/m^2: of the spectral and purple colors locus, of HDTV system primaries triangle and of color gamut area that can be transmitted at relative brightness $Y = 0.6$

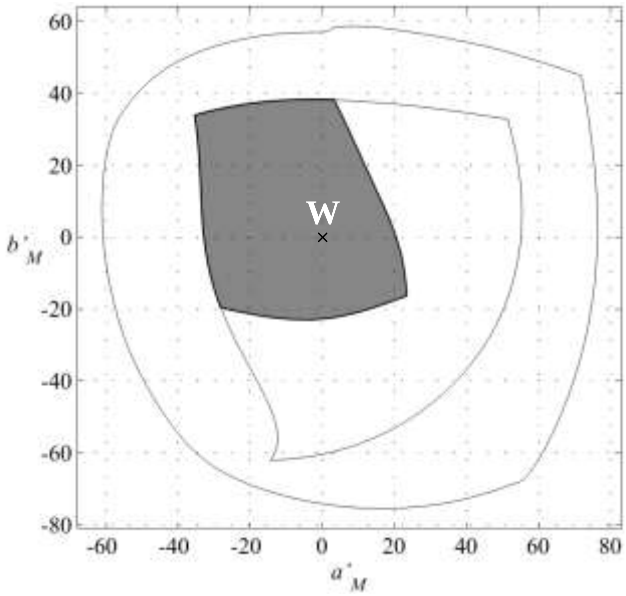

Figure 11 – Representation in CAM02-UCS coordinates for adapting luminance $L_A = 50$ cd/m^2: of the spectral and purple colors locus, of HDTV system primaries triangle and of color gamut area that can be transmitted at relative brightness $Y = 0.6$

The presented method of determining the boundaries of the color gamut transmitted by TV systems with consideration of possible variation the range of primaries signals and limited their maximum luminance on the basis of the conditions for obtaining given reference white color is usable to any video applications, based on the implementation of the additive colorimetry.

This method was used for building the boundaries of the transmitted color gamut in documents [4, 7–9], which show the corresponding estimates in relation to SDTV, HDTV, UHDTV systems, digital cinema systems, and a number of multimedia applications.

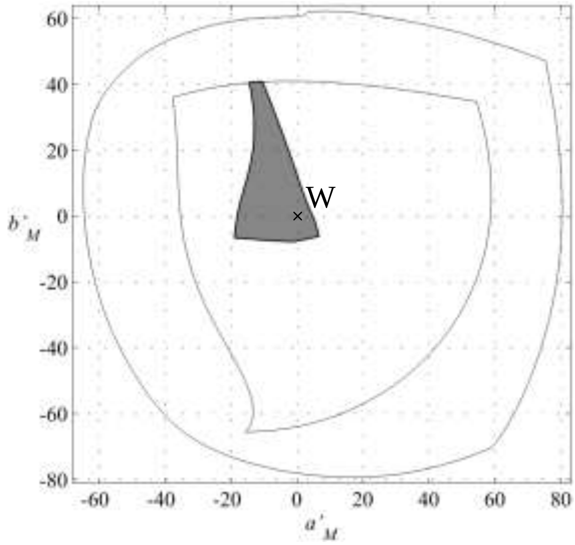

Figure 12 – Representation in CAM02-UCS coordinates for adapting luminance $L_A = 50$ cd/m^2:
of the spectral and purple colors locus, of HDTV system primaries triangle and of color gamut area that can be transmitted at relative brightness $Y = 0.6$

Presentation color gamut in uniform color space is extremely useful as it allows to judge on the real benefits relative to perfection of TV systems and related video applications with direct view of the properties of human color perception under specified conditions.

REFERENCES

1 CIE 159:2004 Technical Report. A Colour Appearance Model for Colour Management Systems: CIECAM02.

2 Mark D. Fairchild Color Appearance Models − Second Edition, Wiley-IS&T series in imaging science and technologies, 2005.

3 M. Ronnier Luo, Guihua Cui, Changjun Li Uniform Colour Spaces based on CIECAM02 Colour Appearance Model – Colour Research and Application, Volume 31, Issue 4, May 2005.

4 Ukraine. Range of colors transmitted and reproduced by TV system. Document 6C/74, October 2012

5 Gofaizen O.V., Pilyavskiy V.V. Color gamut transmitted by digital television systems / Digital Technologies. − 2012. − No. 11. − Pp. 47−70.

6 SMPTE RP 177–1993(R1997) derivation of basic television color equations.

7 Ukraine. Colorimetric characteristics of new video applications: Digital cinema and digital TV systems matching. Document 6C/165. April 2013.

8 Ukraine. Some colour spaces for use in different industries and colour spaces of digital TV systems matching.. Document 6C/166. April 2013.

9 Ukraine. Use of multi-primary reproduction of TV images produced by SDTV, HDTV and UHDTV systems. Document 6C/167. April 2013.