Activity 7

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Objective:
to perform image segmentation by color using two techniques: parametric and non-parametric segmentation

3D objects have varying shades. To consider the shading variations, the image can be represented by normalized chromaticity coordinates (NCC). NCC is a color space that can separate brightness and chromaticity information. In this part of the code, RGB coordinates (imR, imG, and imB) was transformed into normalized chromaticity coordinates (imr, img, and imb), where I (imI) contains the brightness information.

```
image =imread('rubik2.jpg');
figure(1); imshow(image);
im = double(image);
imR = im(:,:,1); imG = im(:,:,2); imB = im(:,:,3);
imI = imR + imG + imB;
imI(imI==0) = 100000;
imr = imR./imI; img = imG./imI; imb = imB./imI;
```

To perform segmentation on the image, a region of interest (roi) must first be extracted. In the code, we cropped a part of the image with the color distribution of interest. Then, the NCC of the cropped region were obtained (roir, roig, and roiI). After this, we proceeded to either parametric or non parametric segmentation.

```
red1 = imcrop(im, [1080 400 40 30]);
red2 = imcrop(im,[550 850 50 40]);
orange1 = imcrop(im, [660 140 40 30]);
orange2 = imcrop(im,[950 930 50 40]);
yellow1 = imcrop(im, [200 520 40 40]);
yellow2 = imcrop(im,[670 980 40 30]);
green1 = imcrop(im,[1000 780 50 40]);
green2 = imcrop(im, [130 880 50 20]);
blue1 = imcrop(im,[160 620 60 40]);
blue2 = imcrop(im,[410 920 50 30]);
white1 = imcrop(im, [730 250 30 30]);
white2 = imcrop(im,[110 780 50 40]);

roi = white2;
roiR = roi(:,:,1); roiG = roi(:,:,2); roiB = roi(:,:,3);
roiI = roiR + roiG + roiB; roiI(roiI==0) = 100000;
roir = roiR./roiI; roig = roiG./roiI;
```

Parametric Segmentation

In parametric segmentation, we determine the probability that a pixel belongs to a region of interest by assuming that the probability is a Gaussian. In the code, the probability that a pixel with chromaticity r (roir) belongs to the region of interest is given by the probr equation (probg equation is for the pixel with chromaticity g [roig]). Then, the joint probability is taken as the product of probr and probg.

```
aver = mean(roir(:));
stdevr = std(roir(:));
probr = (1./(stdevr.*sqrt(2.*pi))).*exp(-1.*((imr-aver).^2)./(2.*stdevr.^2));
aveg = mean(roig(:));
stdevg = std(roig(:));
probg = (1./(stdevg.*sqrt(2.*pi))).*exp(-1.*((img-aveg).^2)./(2.*stdevg.^2));
jointprob = probr.*probg;
```

Nonparametric Segmentation

In non-parametric segmentation, probability distribution parameters (e.g. mean and standard deviation) are not used. Instead, a non-parametric technique called histogram backprojection is utilized. Histogram projection is done by replacing every pixel in the image with its histogram value in chromaticity space. In the code, we created a 2d histogram (hist) of the region of interest. The, we projected the histogram to the original image. Note that we set the number of bins to 32, resulting to a histogram with 32 x 32 dimensions.

Nonparametric Segmentation

```
bin = 32;
intr = round(roir*(bin-1)+1);
intg = round(roig*(bin-1)+1);
color = intg(:) + (intr(:)-1)*bin;
hist = zeros(bin,bin);
for row = 1:bin
    for column = 1:(bin-row+1)
        hist(row,column) = length(find(color ==(((column+(row-1)*bin)))));
    end
end

imsize = size(imr); npsroi  = zeros(imsize(1),imsize(2));
for i = 1:imsize(1)
    for j = 1:imsize(2)
        rnew = round(imr(i,j)*(bin-1)+1);
        gnew = round(img(i,j)*(bin-1)+1);
        npsroi(i,j) = hist(rnew,gnew);
    end
end
```

Original Image

ROI

- Top red
- Side red
- Top orange
- Side orange
- Top yellow
- Side yellow
- Top green
- Side green
- Top blue
- Side blue
- Top white
- Side white

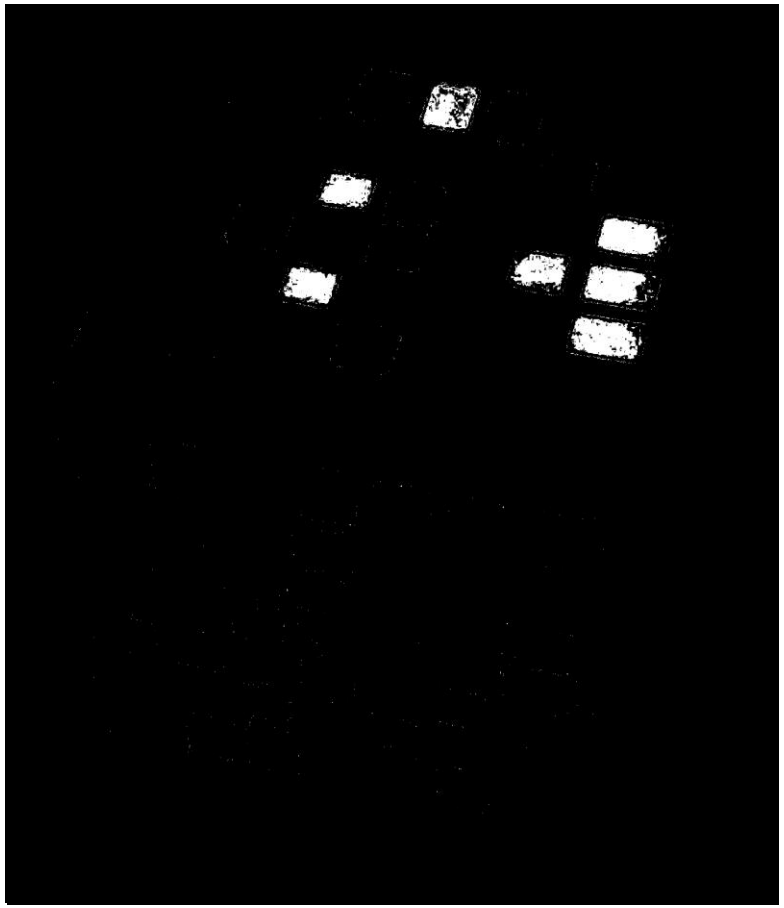
Both segmentation techniques were performed on the Rubik's cube image.

ROI

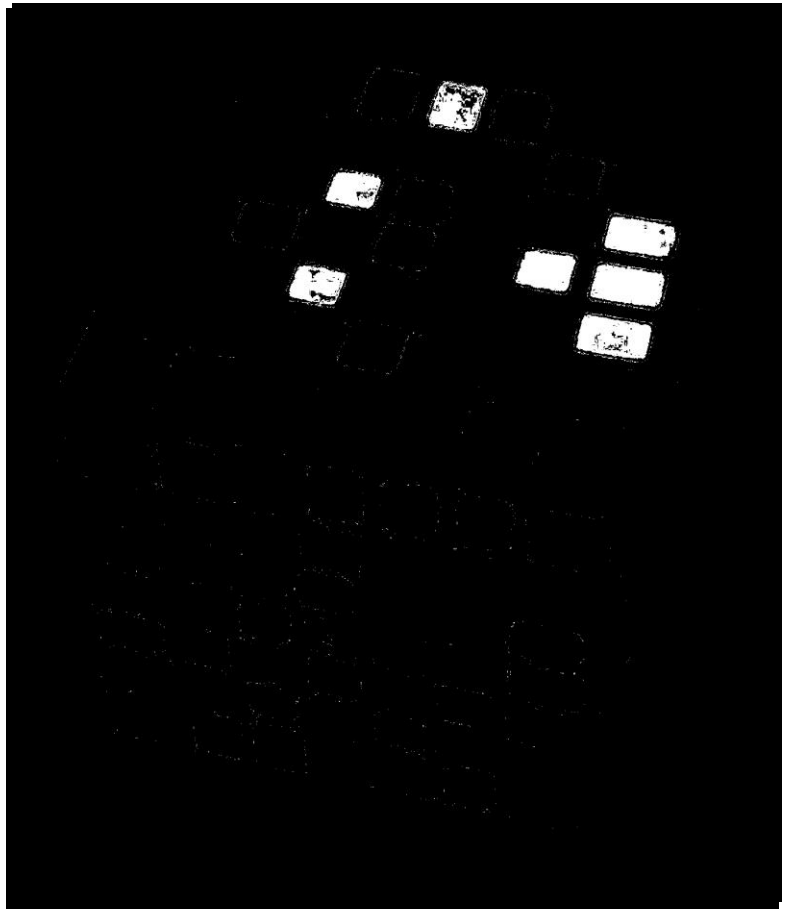
Top view red

Original Image

Parametric Segmentation



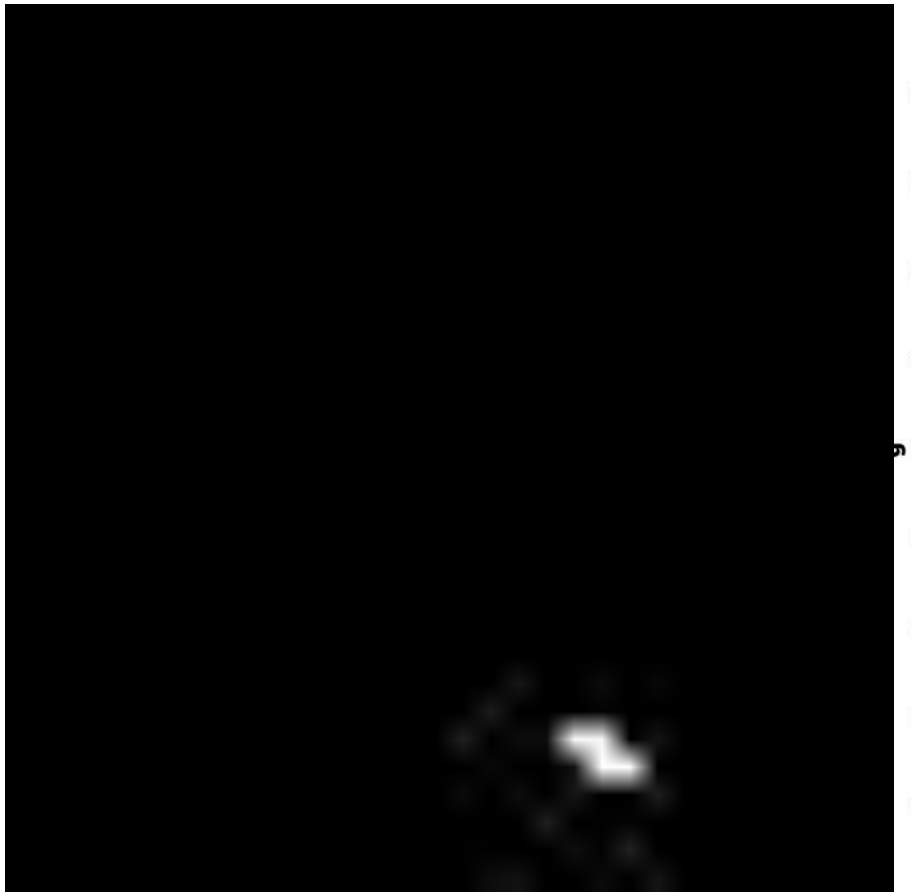
Nonparametric Segmentation



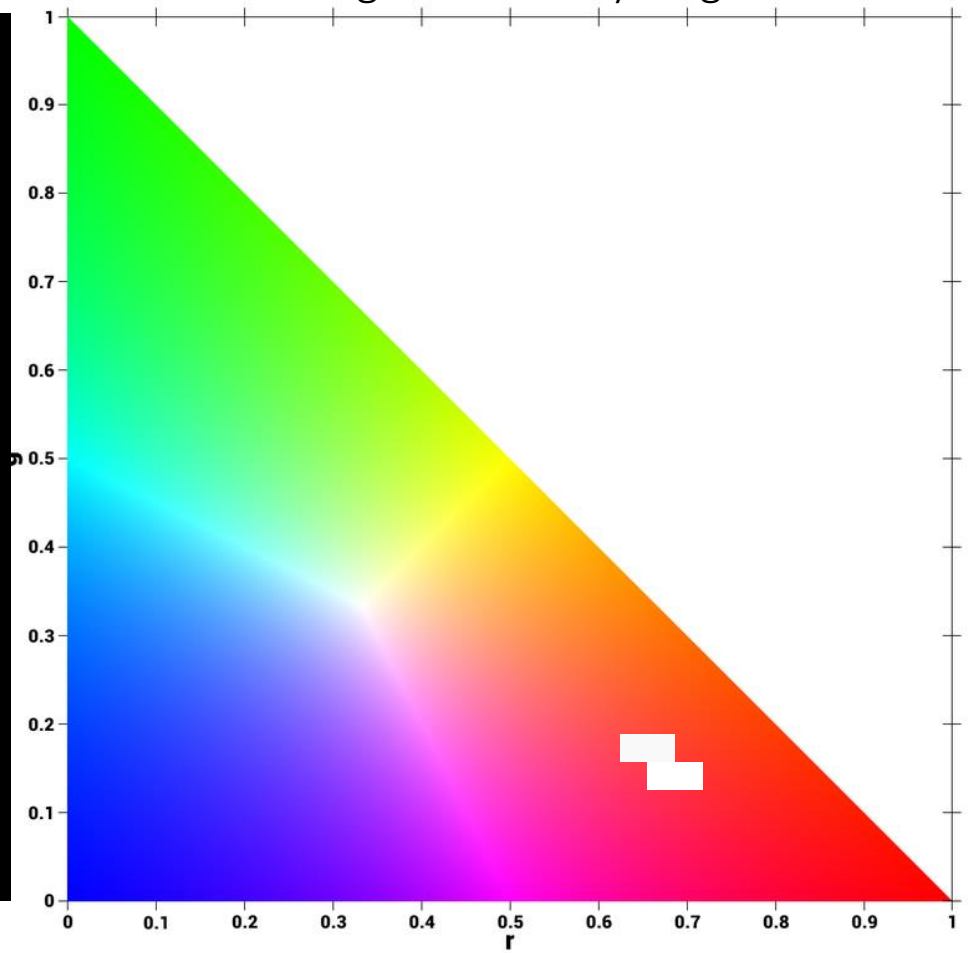
ROI

Top view red

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



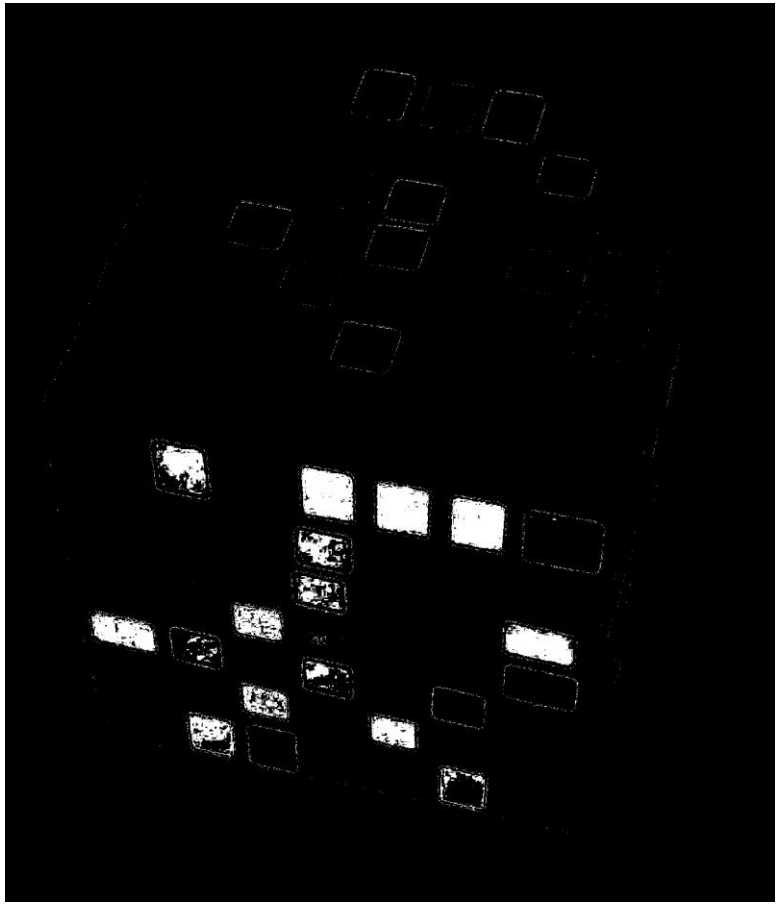
Here, we see if the histogram generated during segmentation is correct by overlaying the peaks of the histogram (white blot) on the rg chromaticity diagram. As shown, histogram peaks correspond to the red area of the rg chromaticty diagram.

ROI

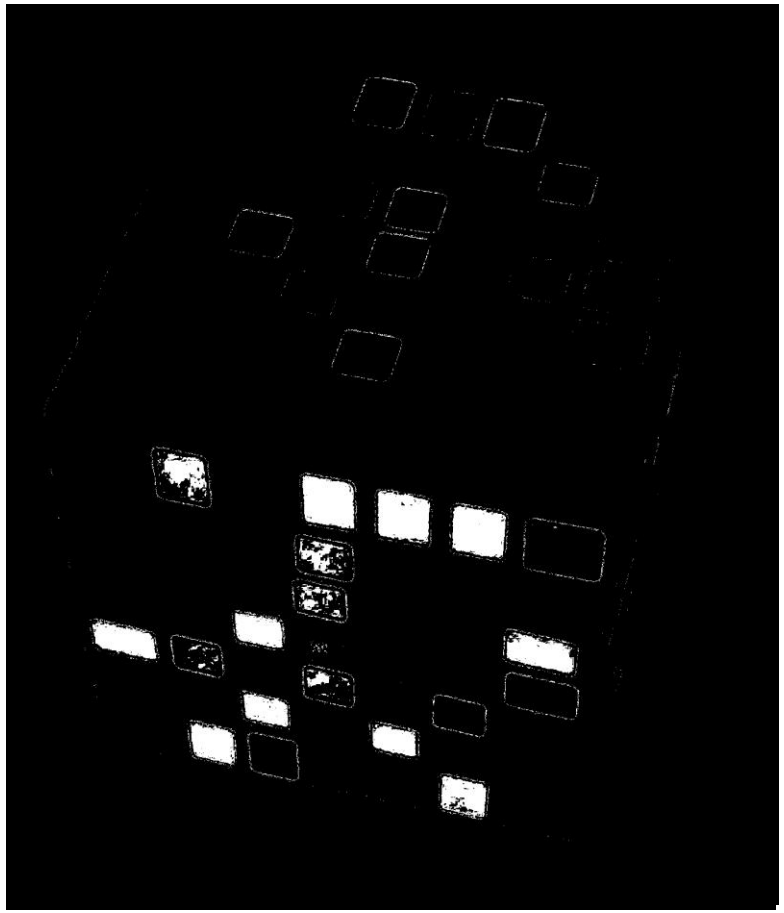
Side view red

Original Image

Parametric Segmentation



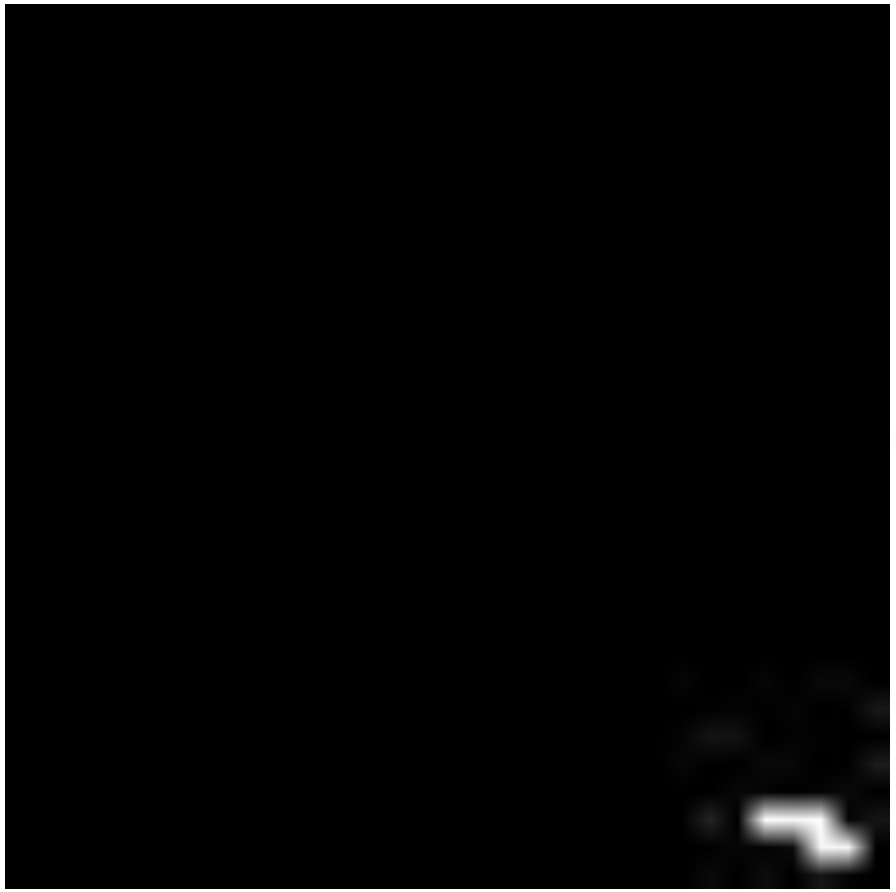
Nonparametric Segmentation



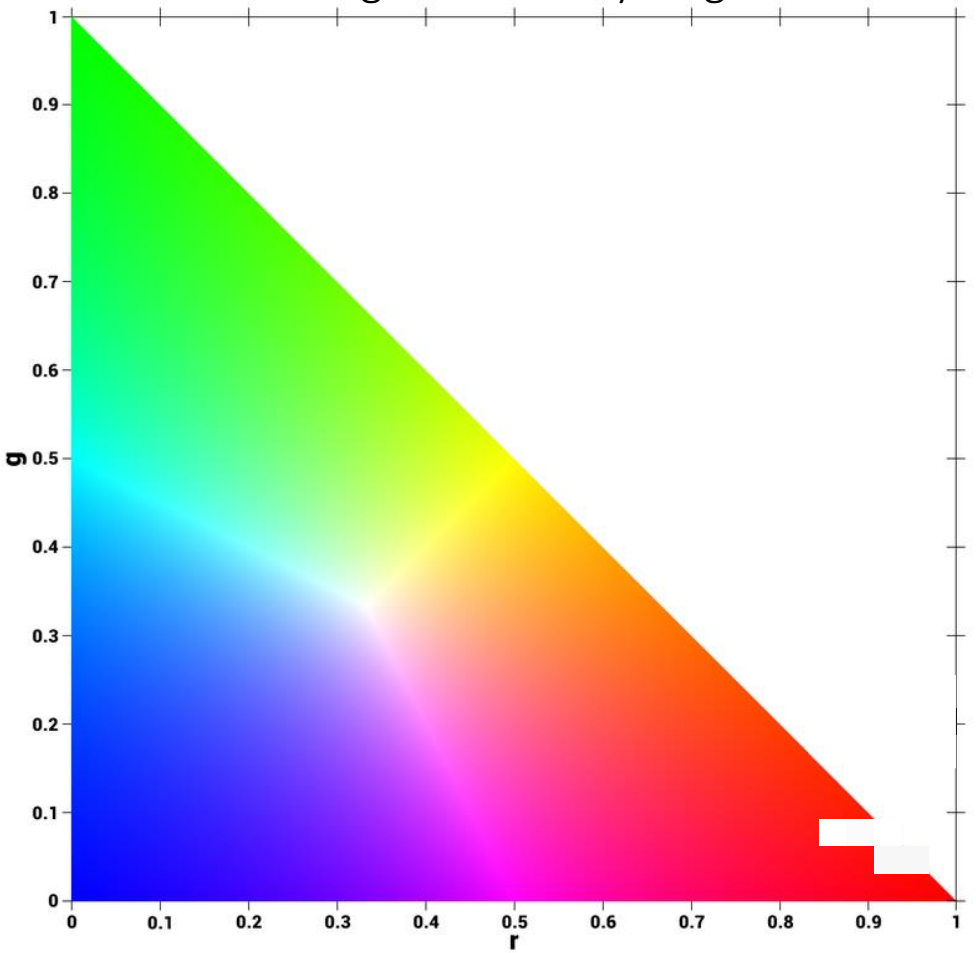
ROI

Side view red

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



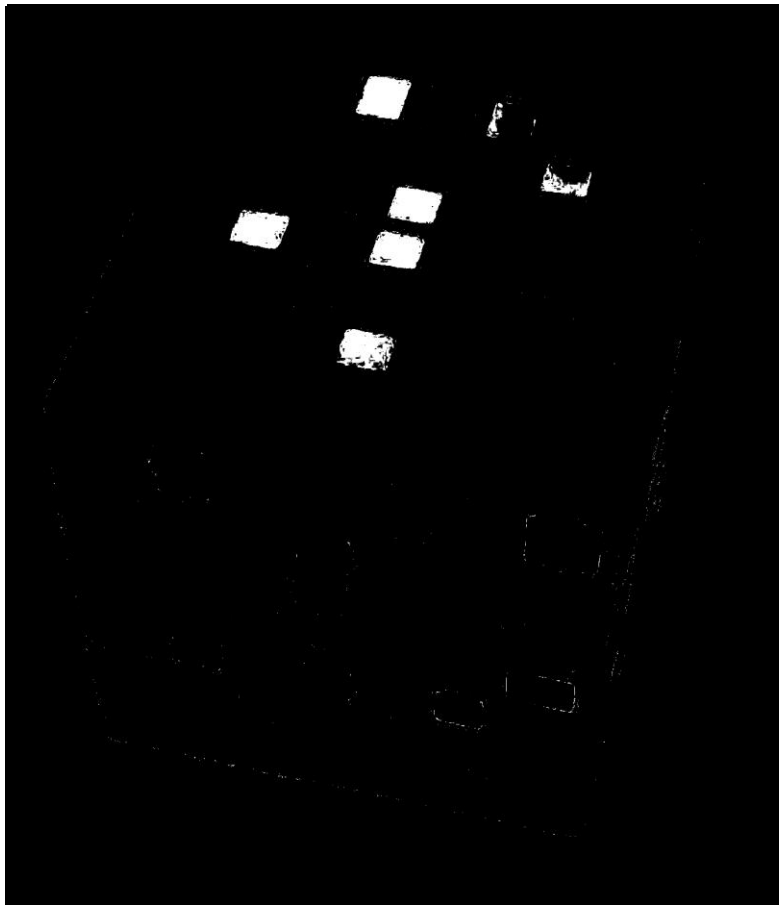
As shown, histogram peaks (white blot) used in segmentation correspond to the red area of the rg chromaticty diagram.

ROI

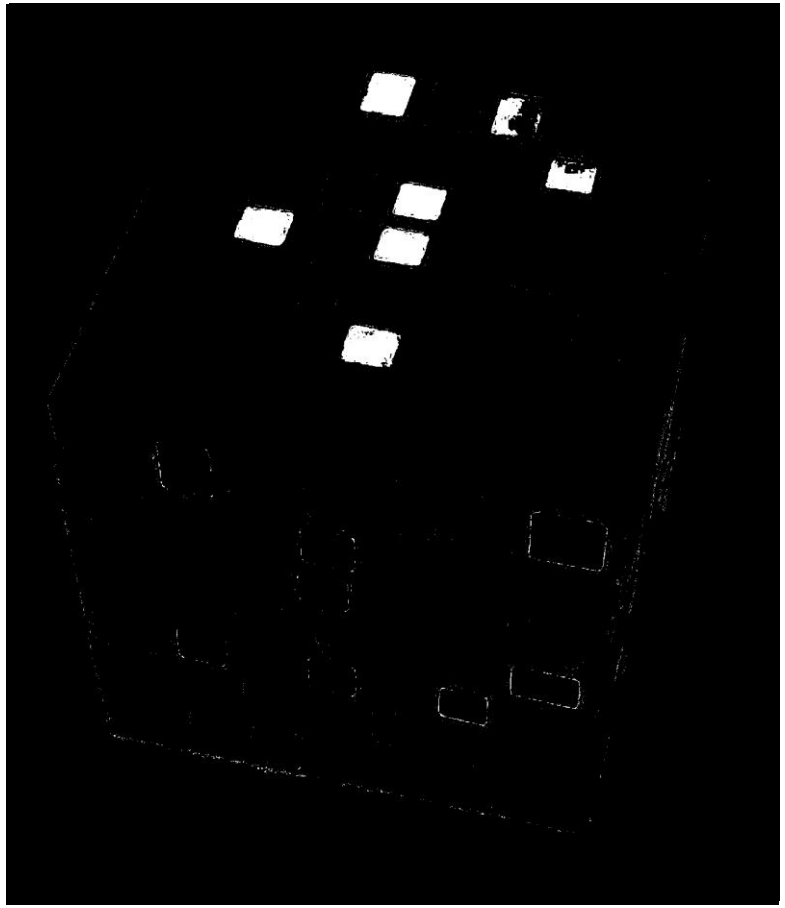
Top view orange

Original Image

Parametric Segmentation



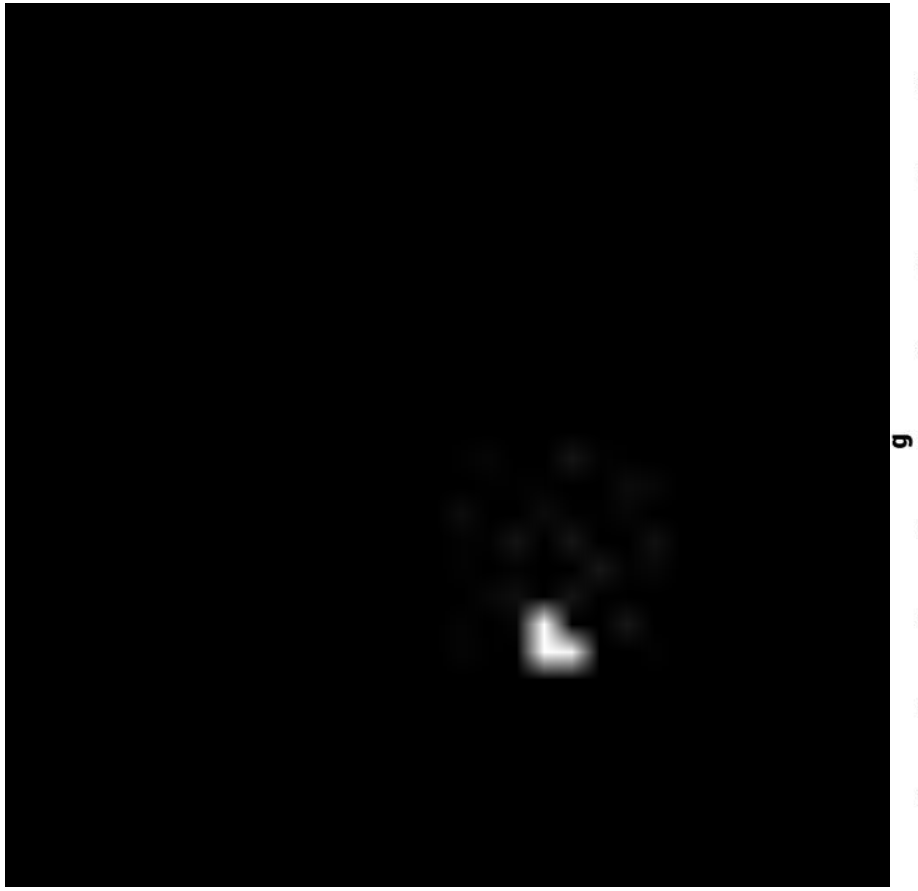
Nonparametric Segmentation



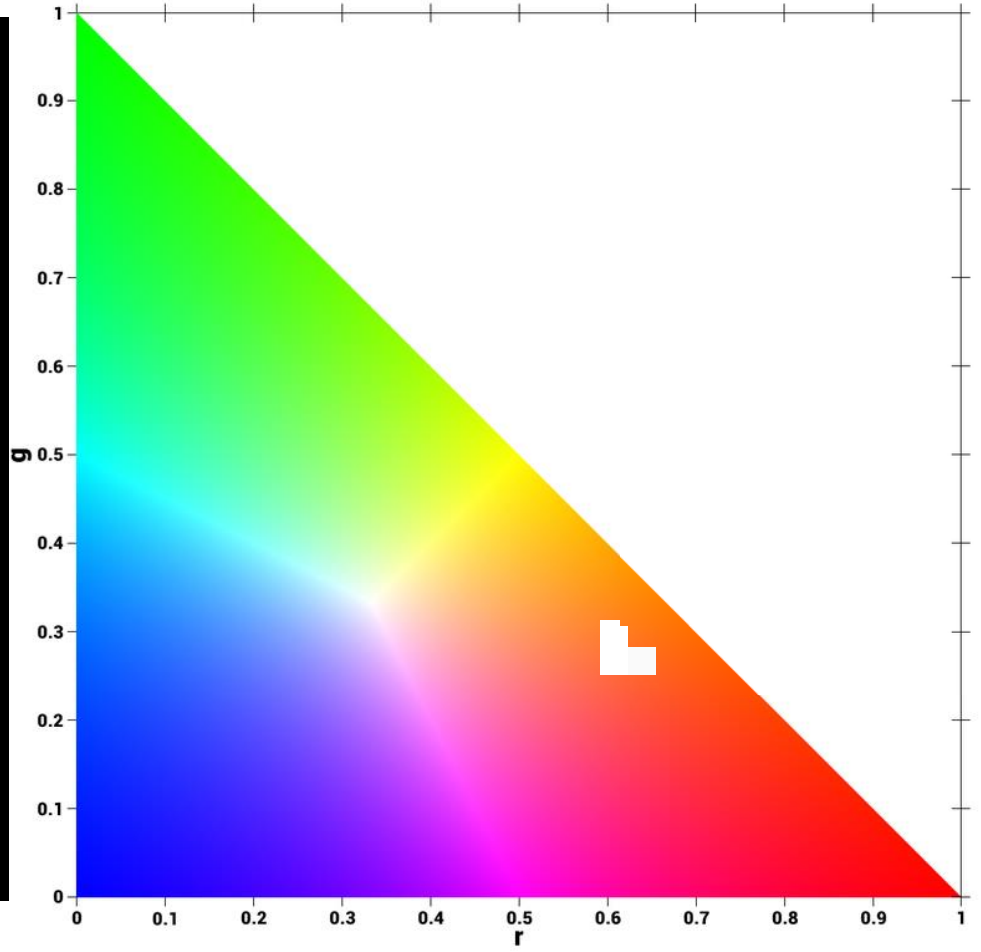
ROI

Top view orange

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



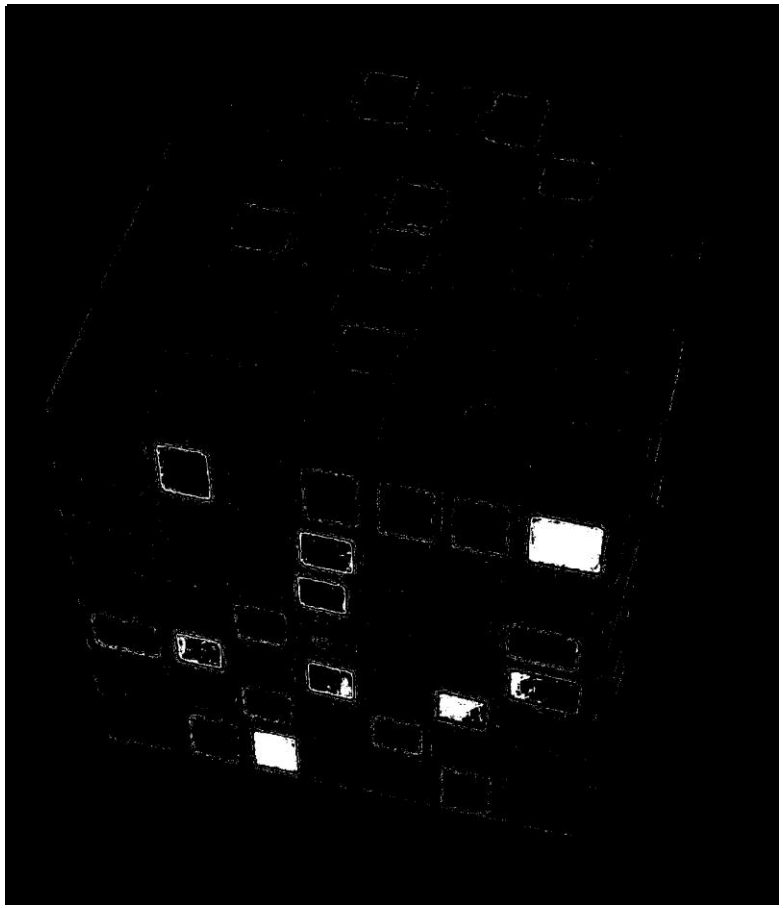
As shown, histogram peaks (white blot) used in segmentation correspond to the orange area of the rg chromaticty diagram.

ROI

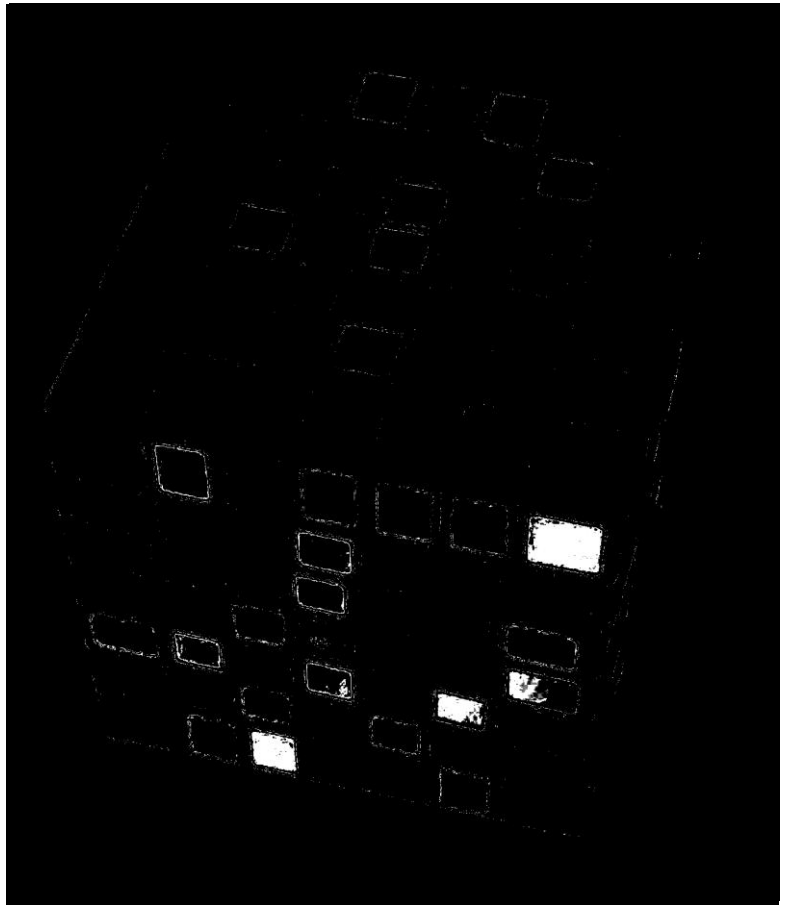
Side view orange

Original Image

Parametric Segmentation



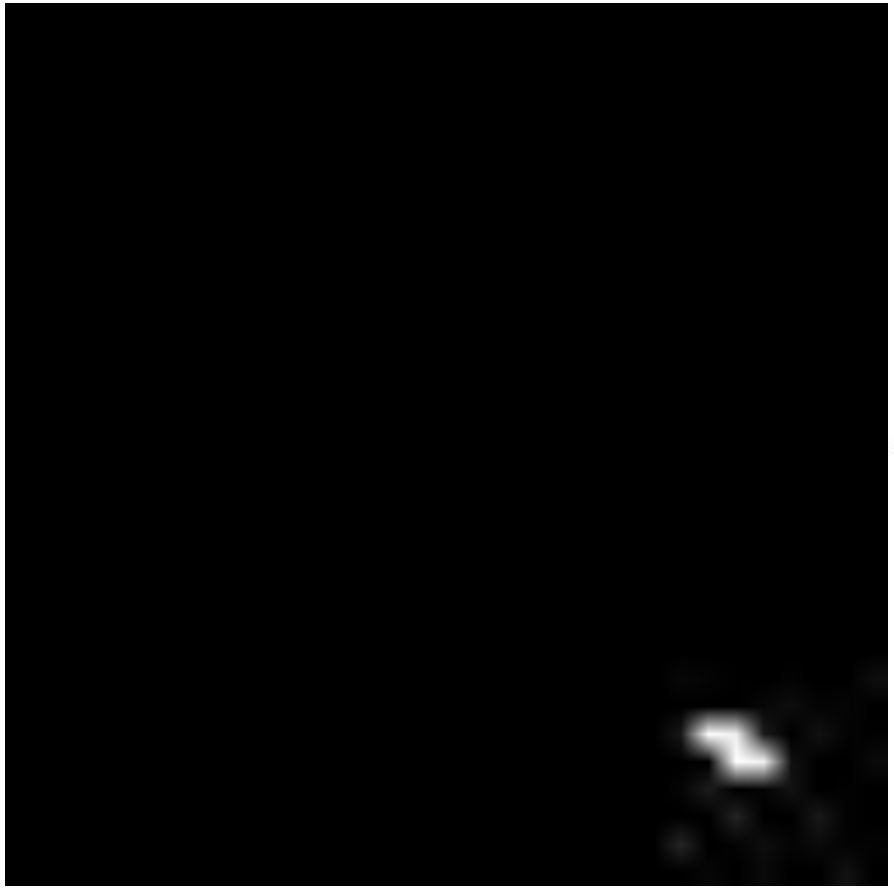
Nonparametric Segmentation



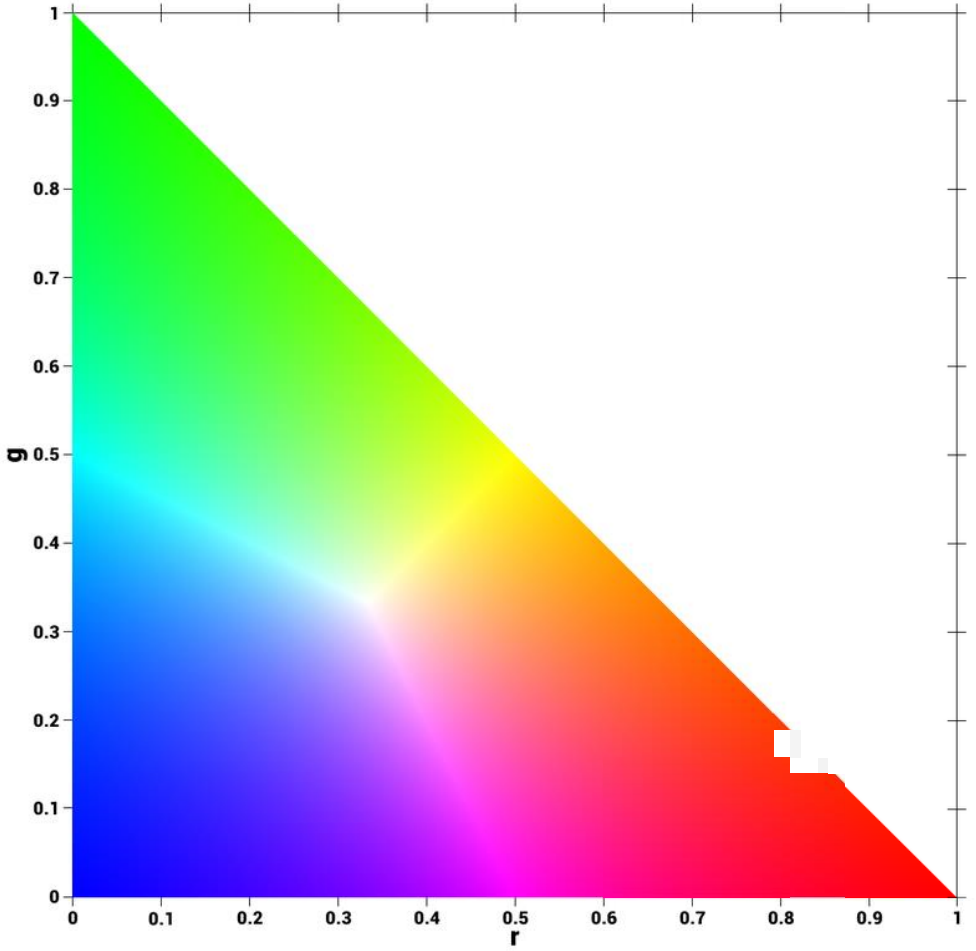
ROI

Side view orange

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



As shown, histogram peaks (white blot) used in segmentation correspond to the orange area of the rg chromaticty diagram.

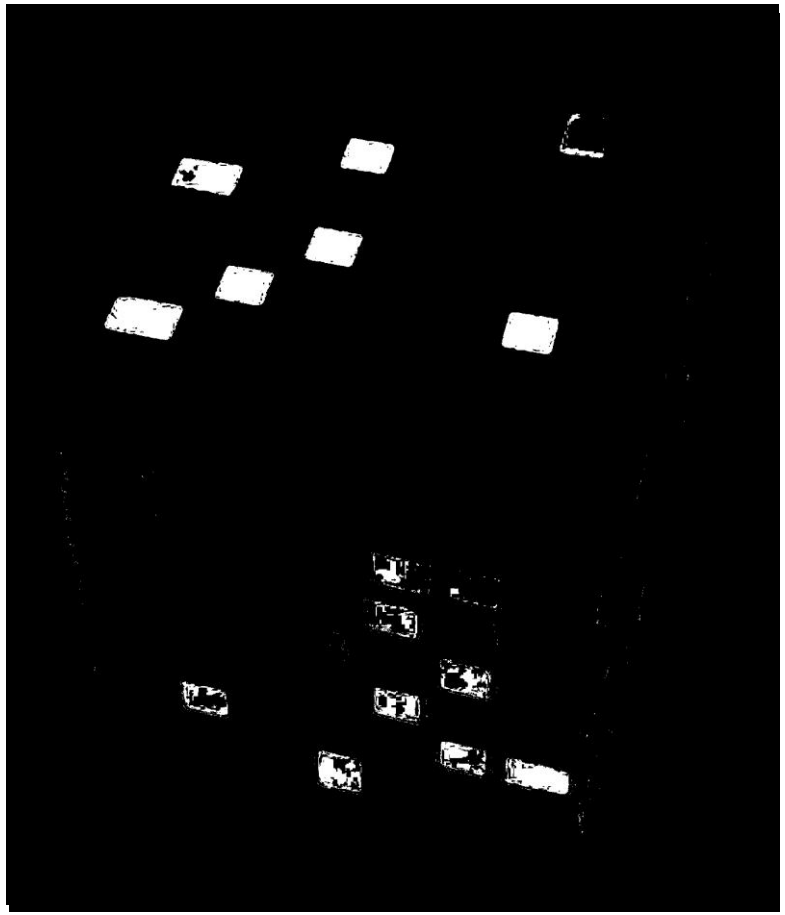
ROI

Top view yellow

Original Image

Parametric Segmentation

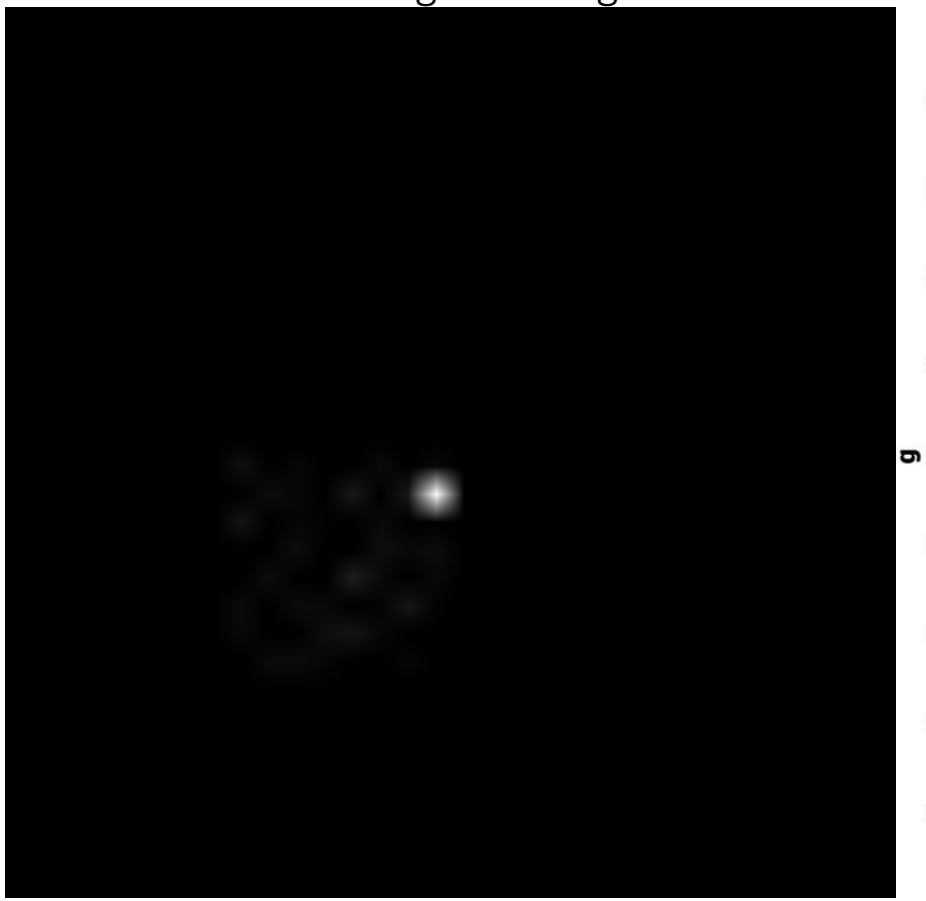
Nonparametric Segmentation



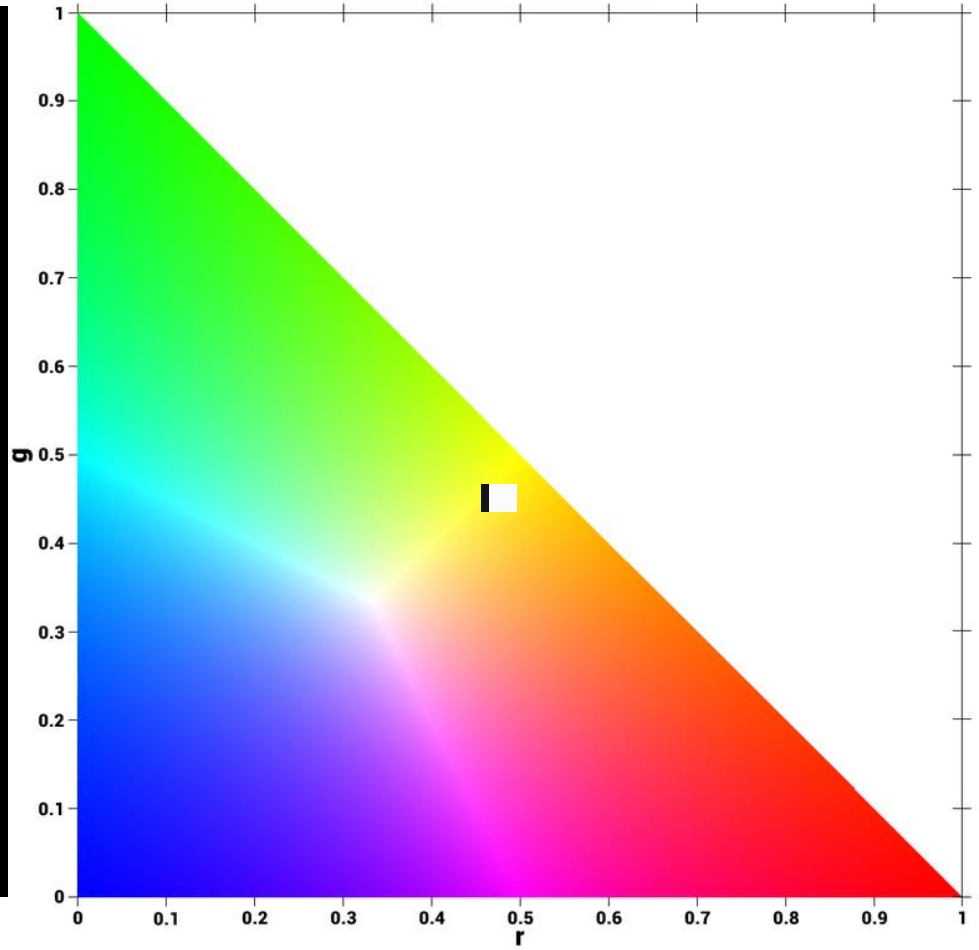
ROI

Top view yellow

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



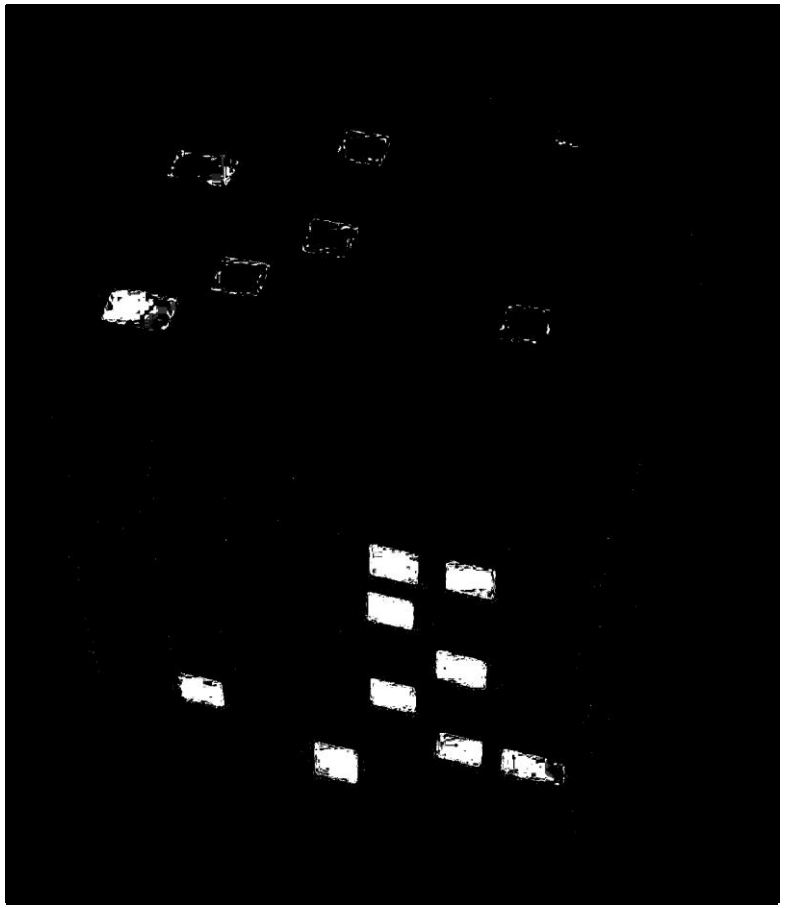
As shown, histogram peaks (white blot) used in segmentation correspond to the yellow area of the rg chromaticty diagram.

ROI

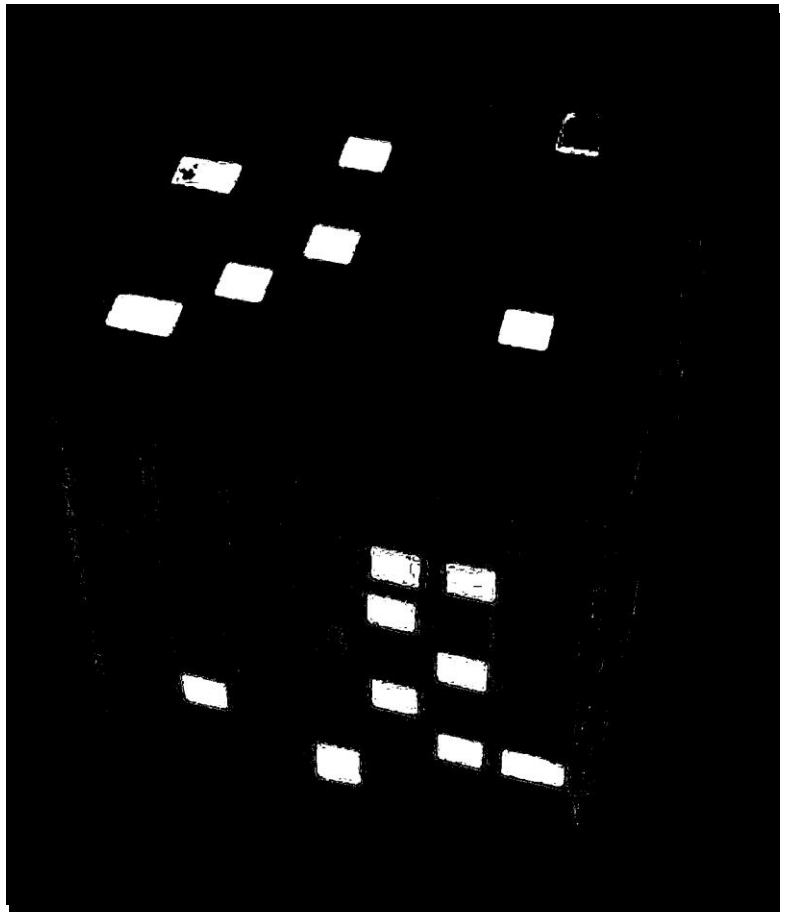
Side view yellow

Original Image

Parametric Segmentation



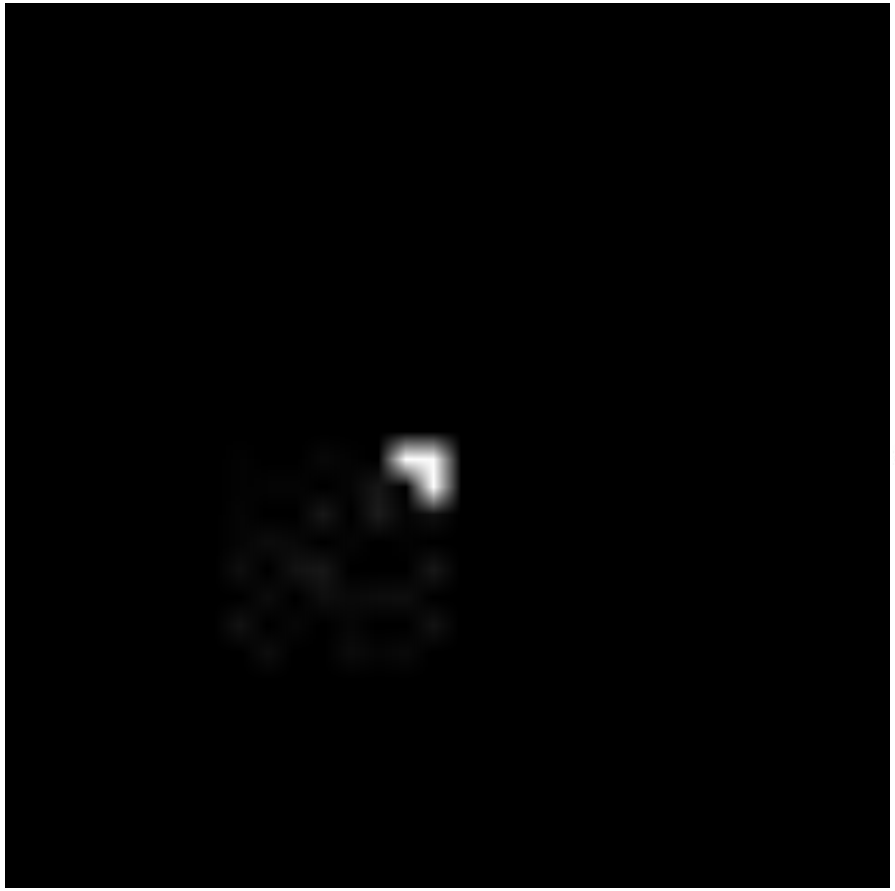
Nonparametric Segmentation



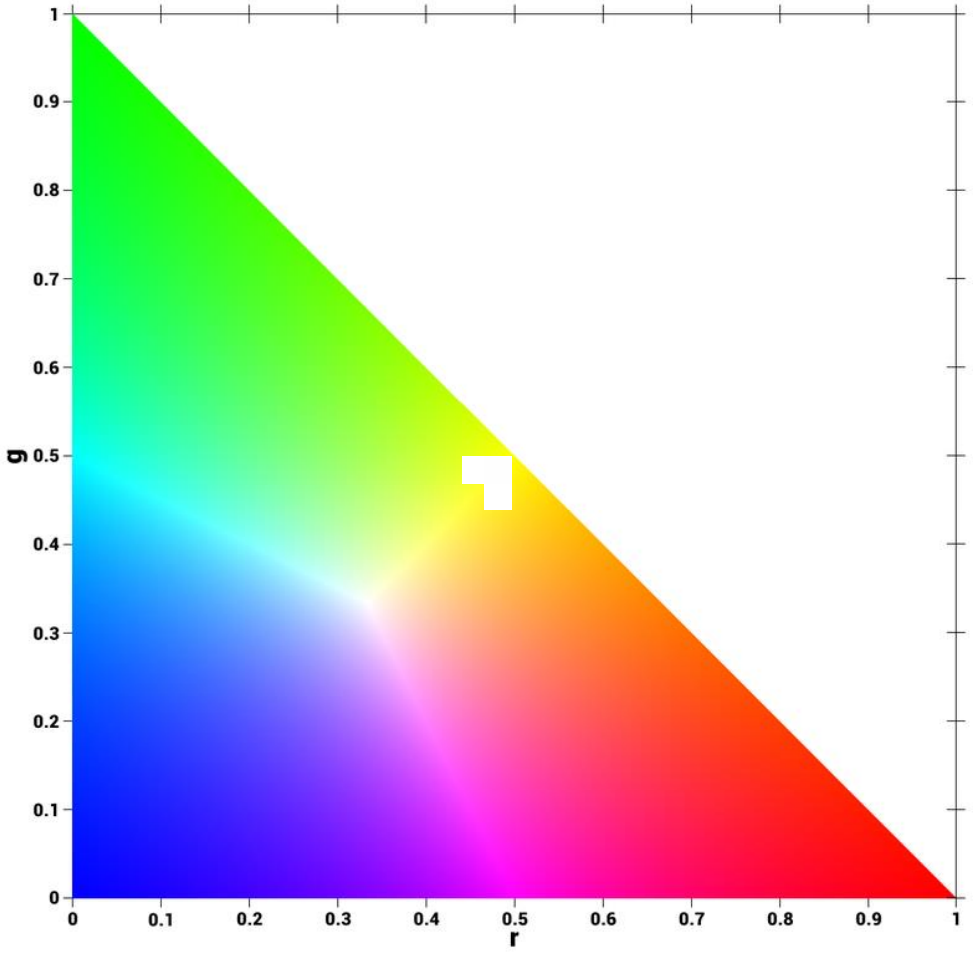
ROI

Side view yellow

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



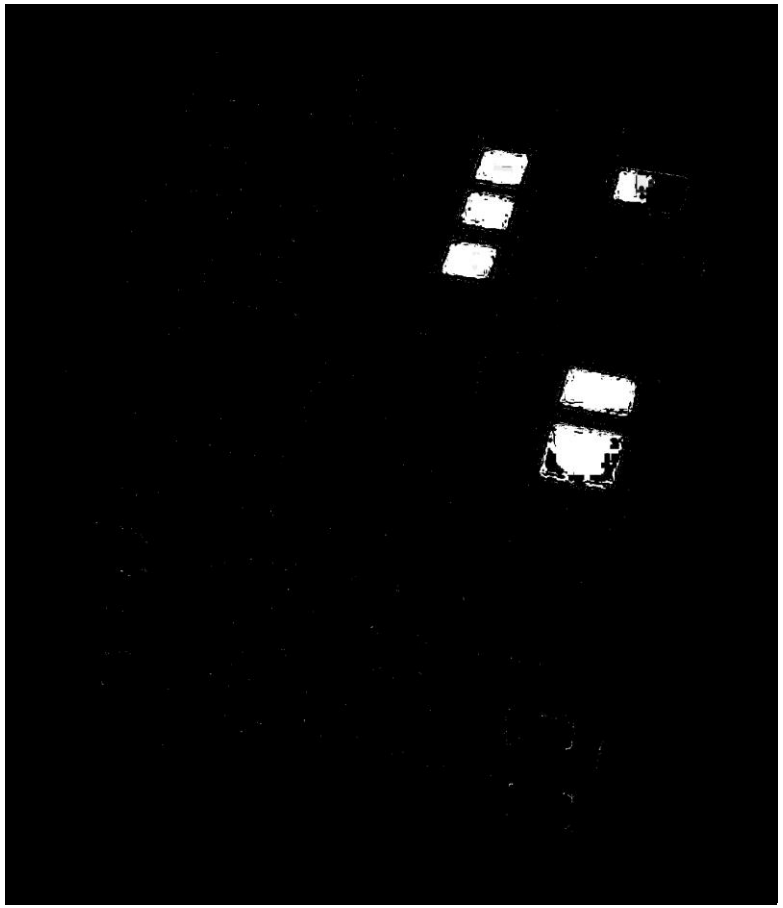
As shown, histogram peaks (white blot) used in segmentation correspond to the yellow area of the rg chromaticty diagram.

ROI

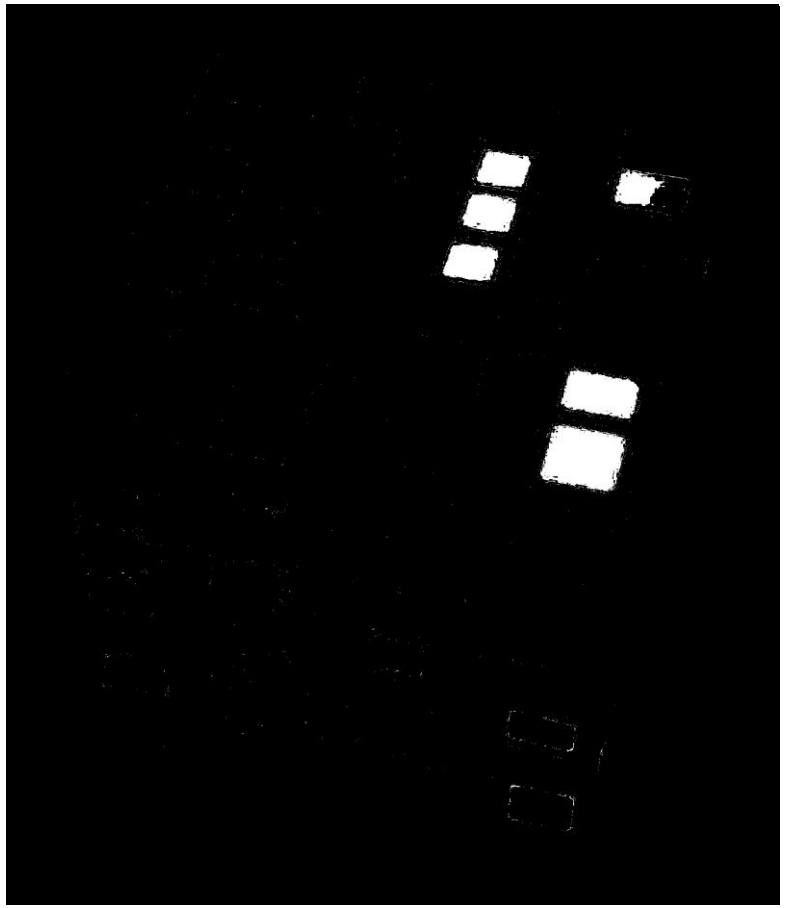
Top view green

Original Image

Parametric Segmentation



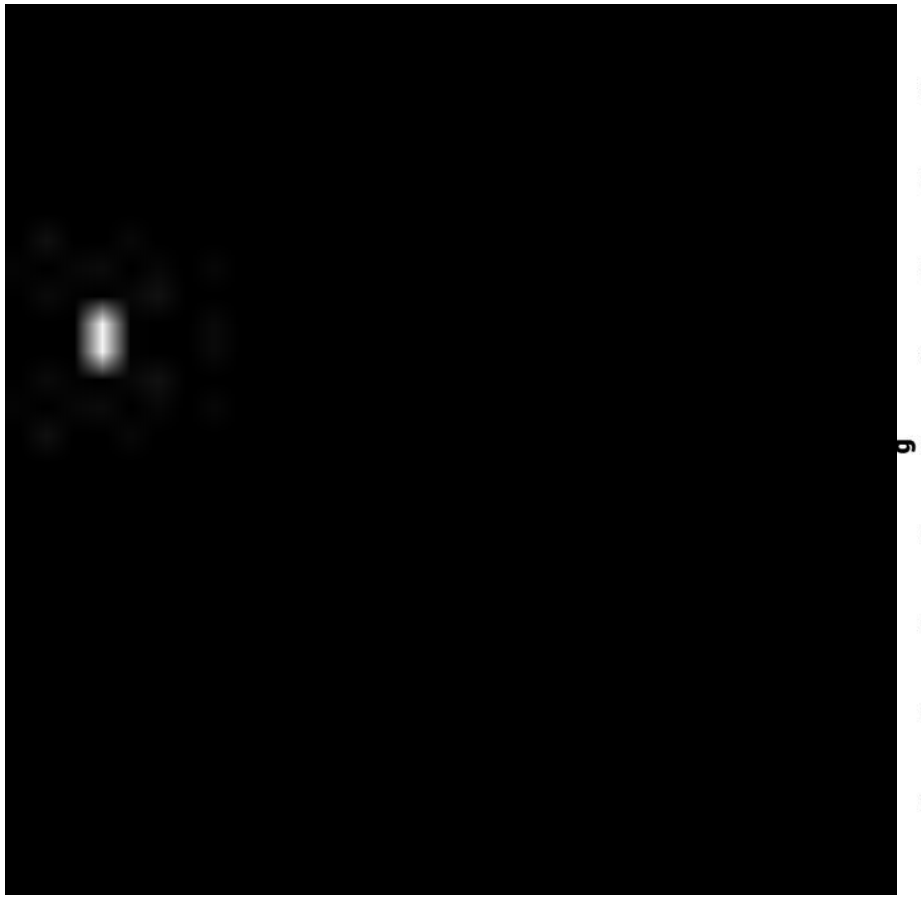
Nonparametric Segmentation



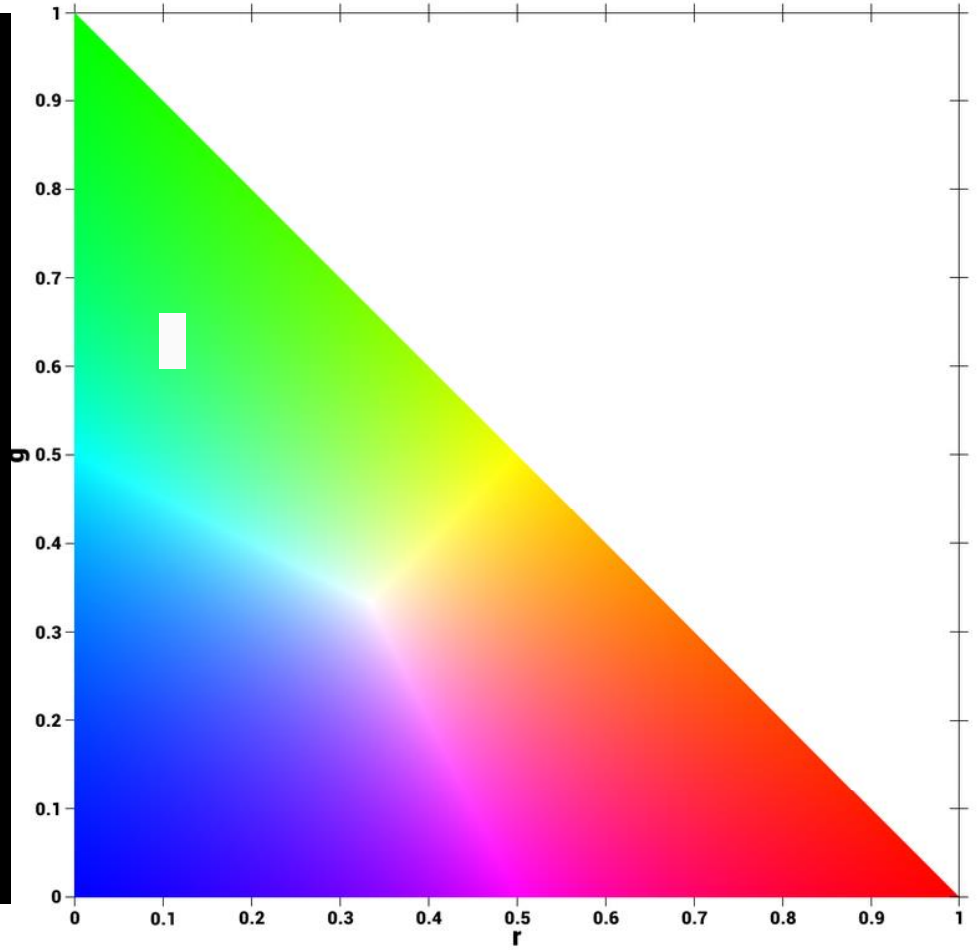
ROI

Top view green

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



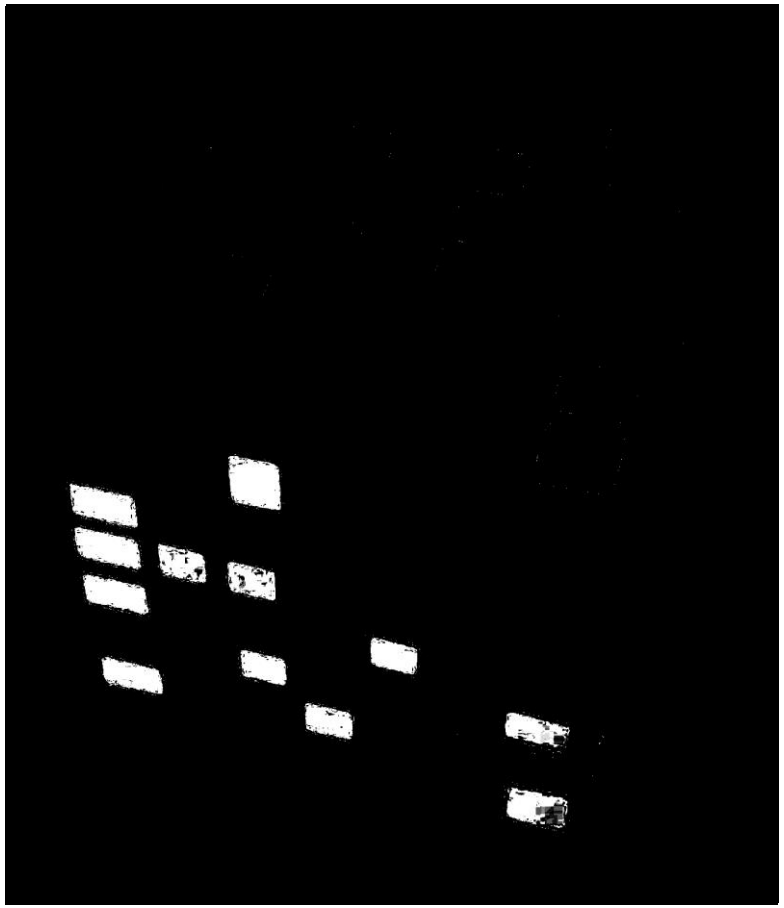
As shown, histogram peaks (white blot) used in segmentation correspond to the green area of the rg chromaticty diagram.

ROI

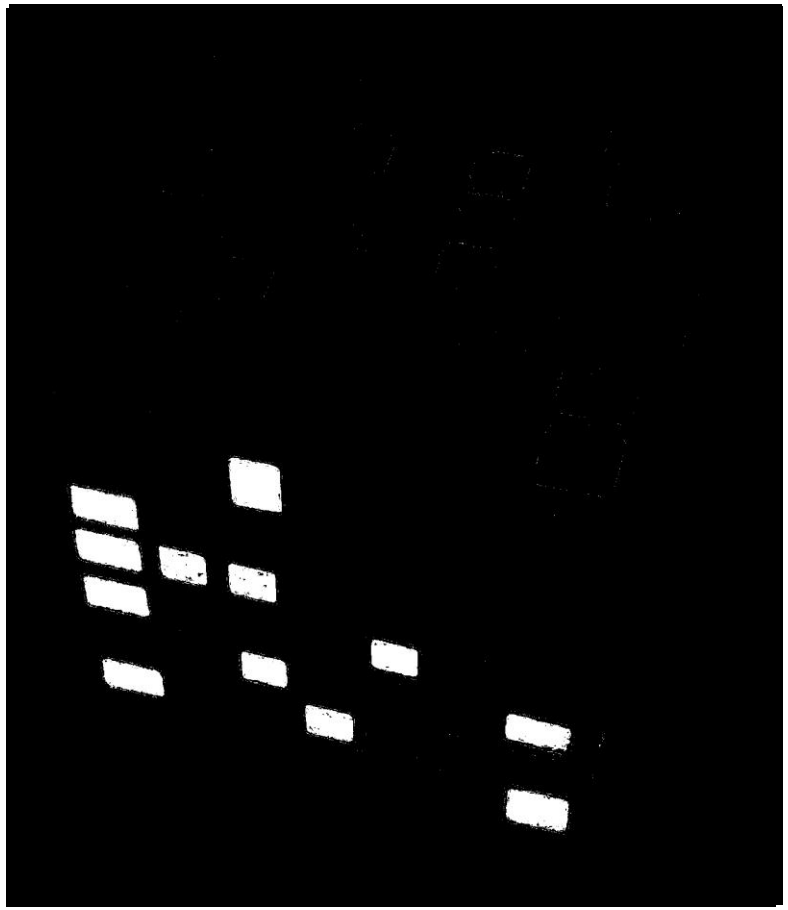
Side view green

Original Image

Parametric Segmentation

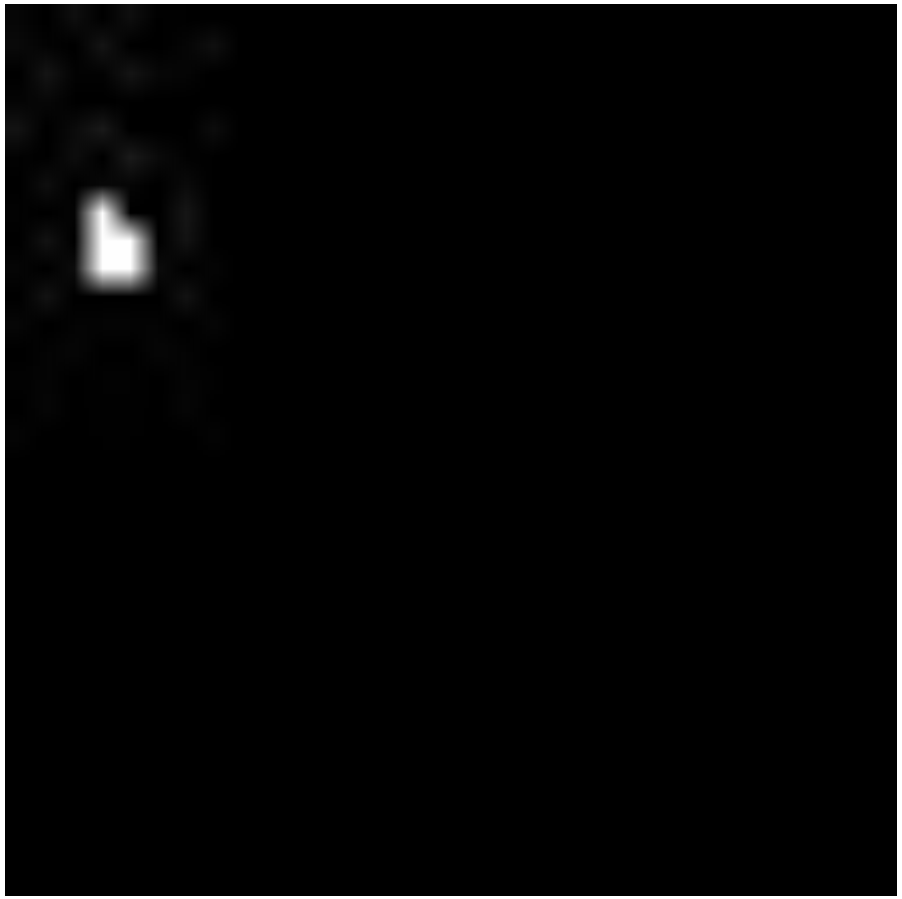


Nonparametric Segmentation

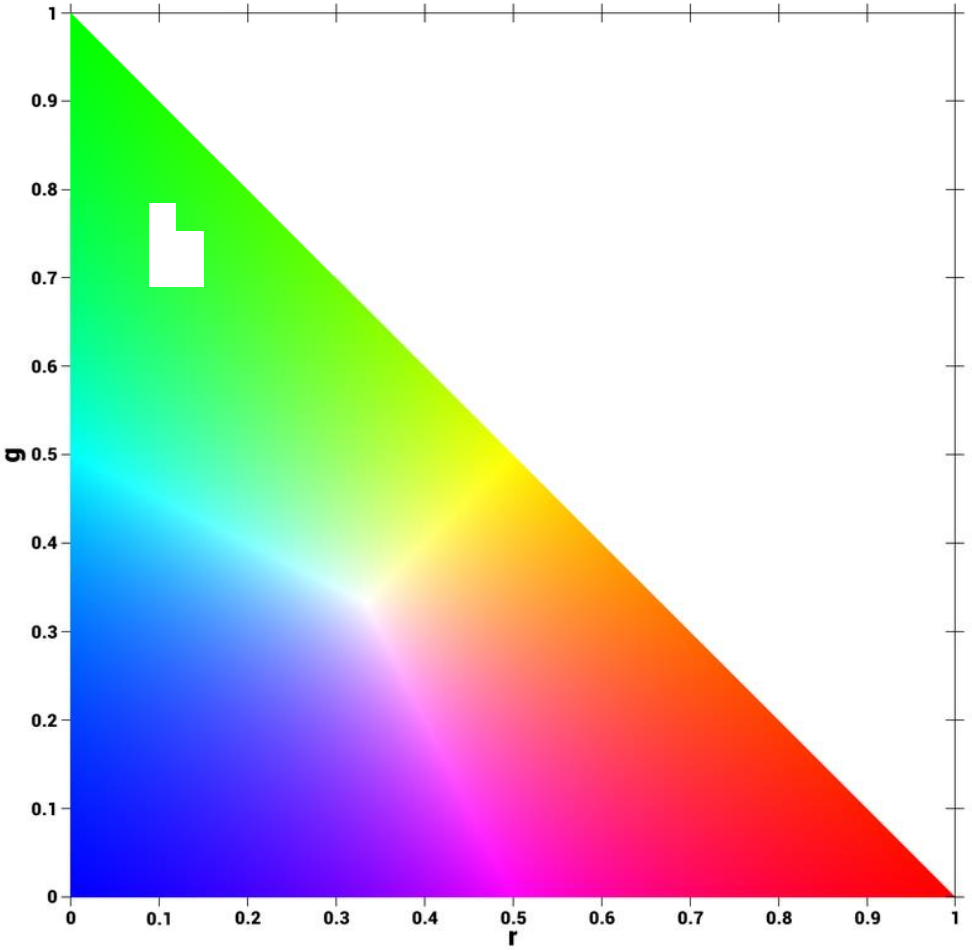


ROI

Side view green



Peak location of histogram (white blot)
in the rg chromaticity diagram



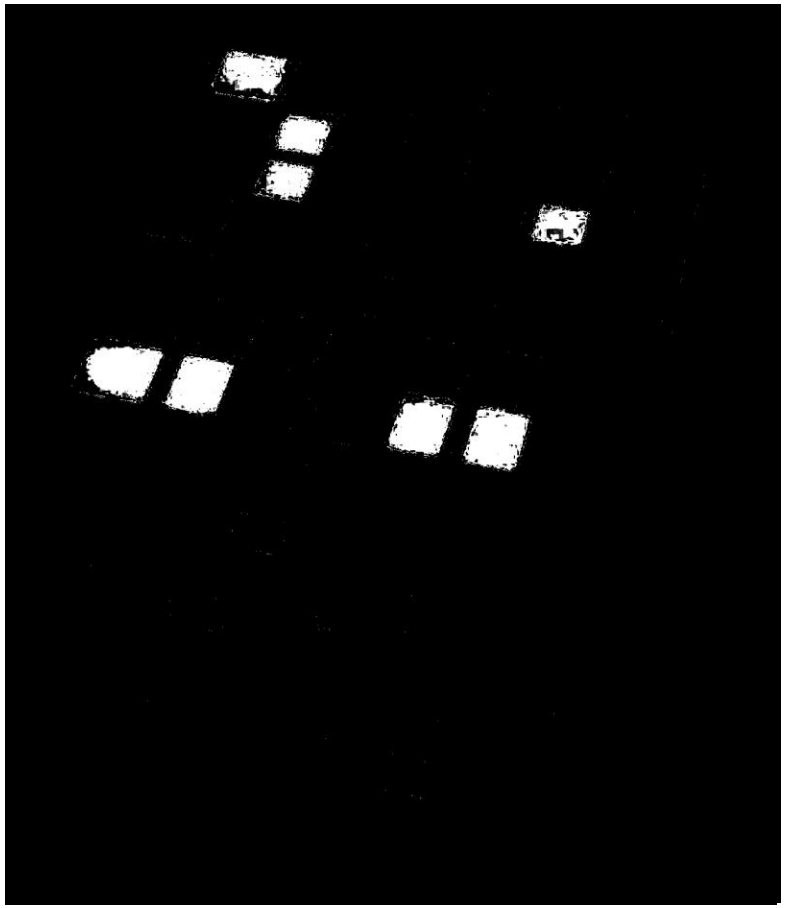
As shown, histogram peaks (white blot) used in segmentation correspond to the green area of the rg chromaticty diagram.

ROI

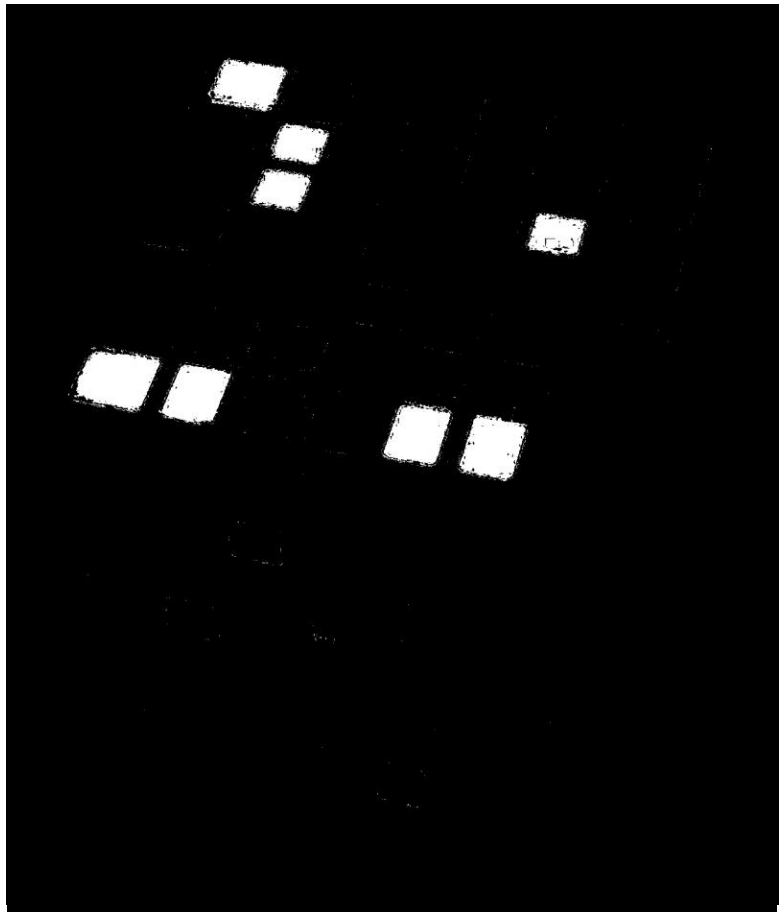
Top view blue

Original Image

Parametric Segmentation



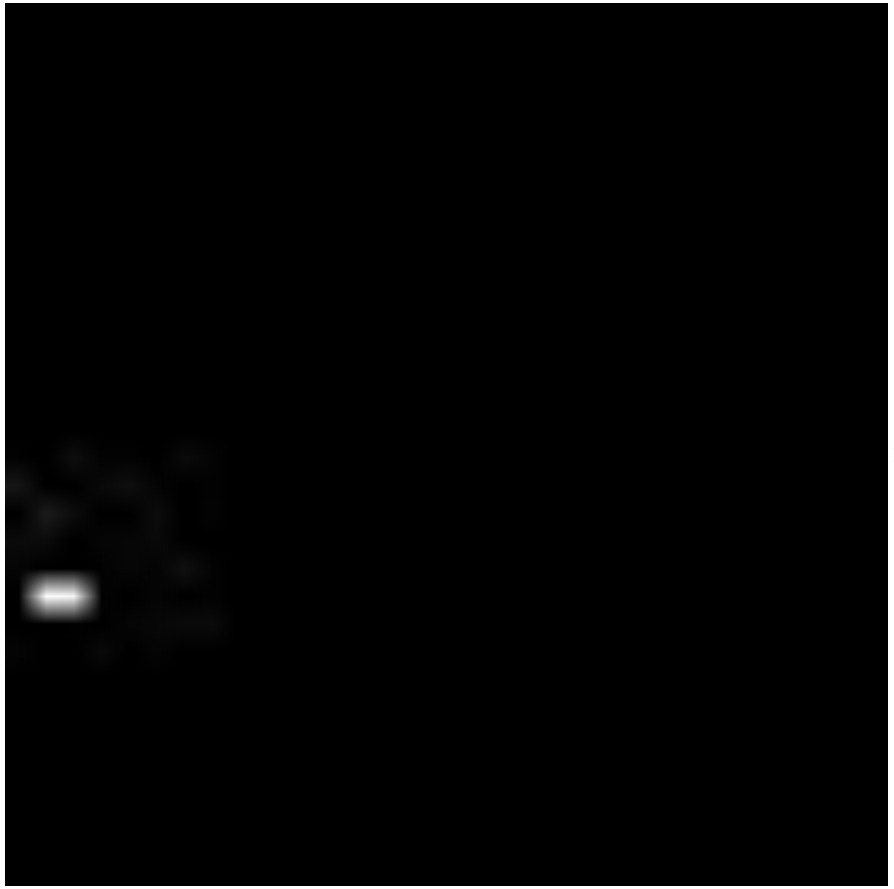
Nonparametric Segmentation



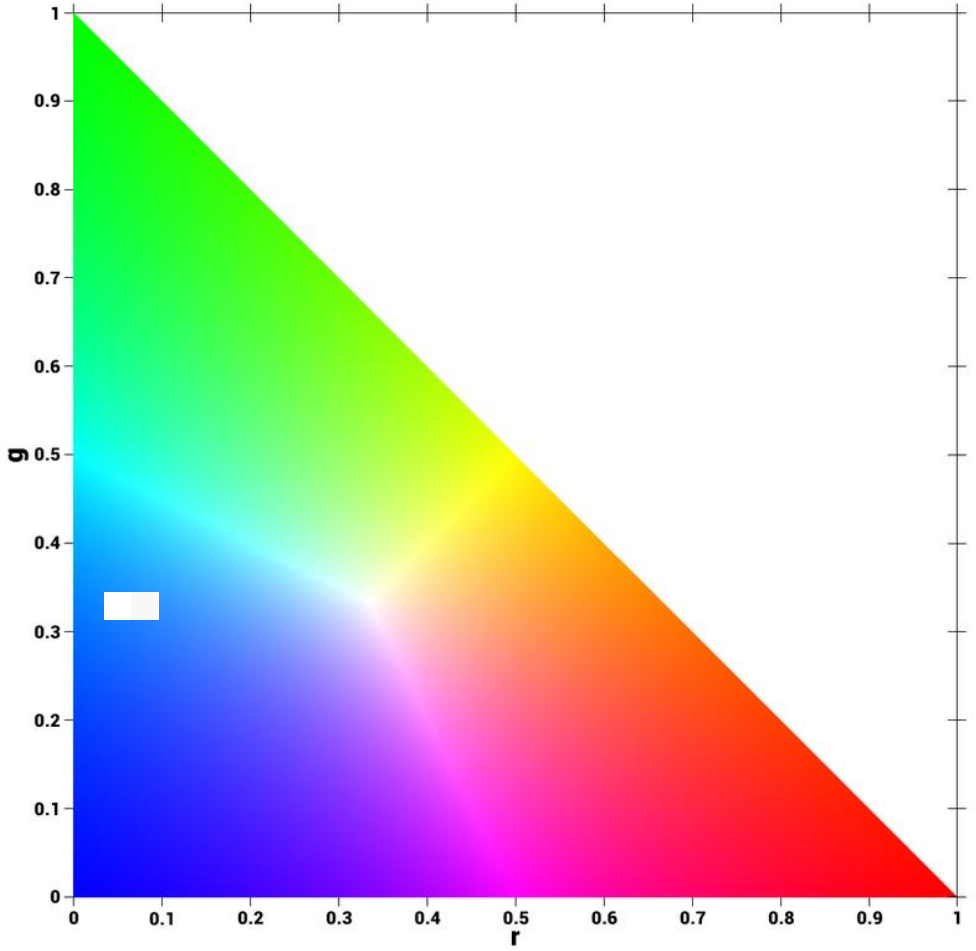
ROI

Top view blue

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



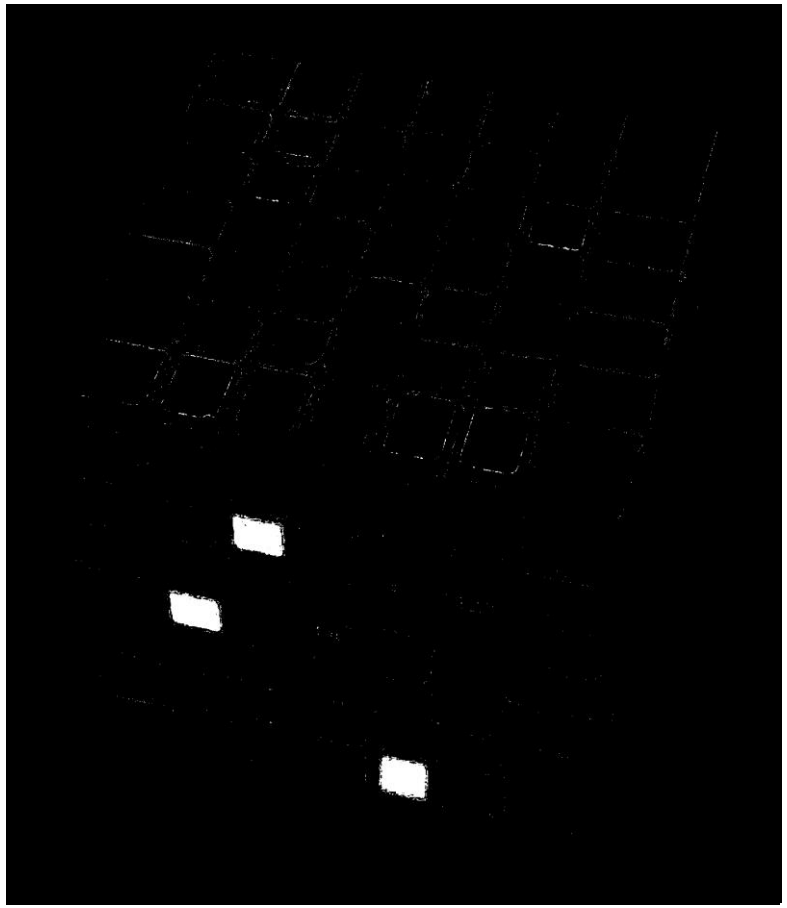
As shown, histogram peaks (white blot) used in segmentation correspond to the blue area of the rg chromaticty diagram.

ROI

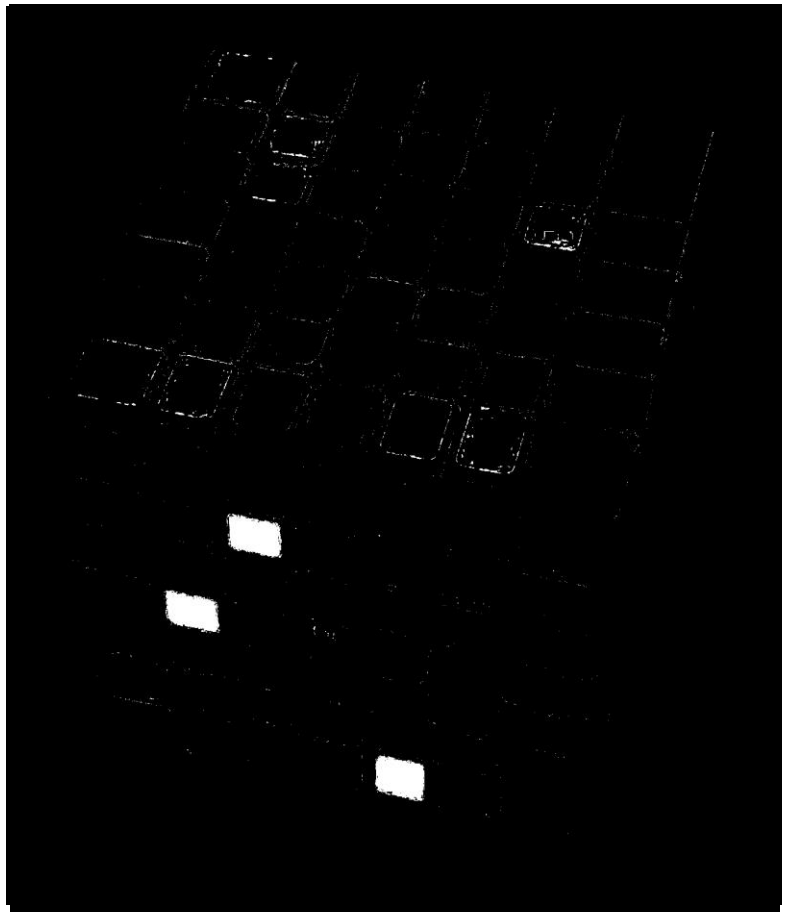
Side view blue

Original Image

Parametric Segmentation



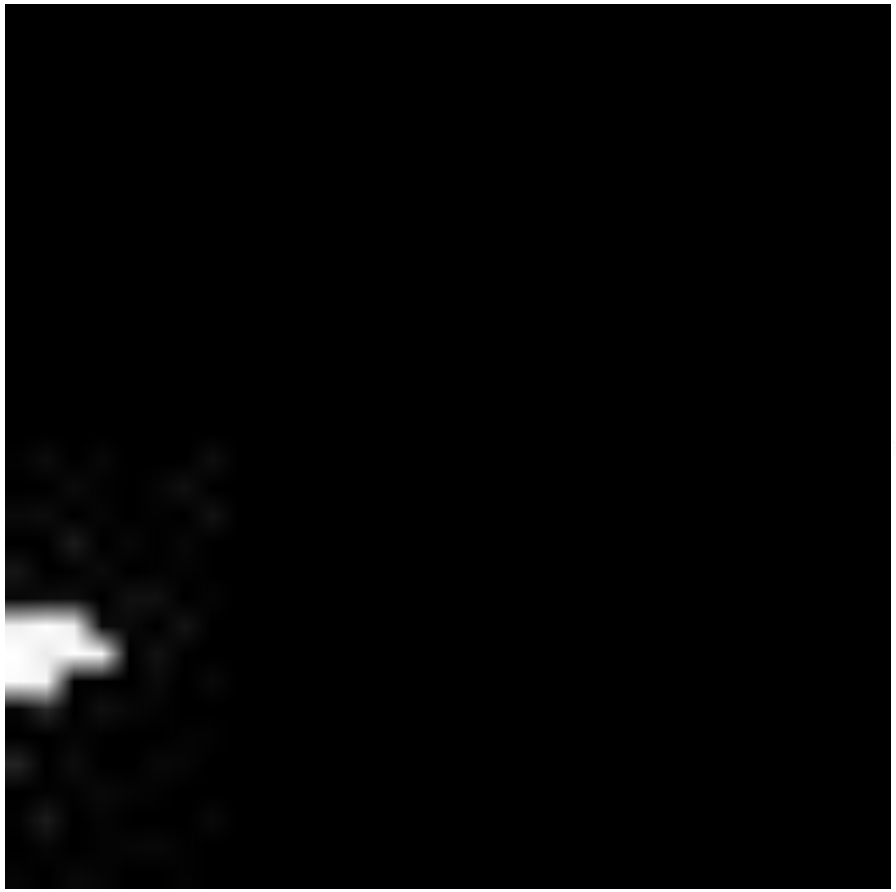
Nonparametric Segmentation



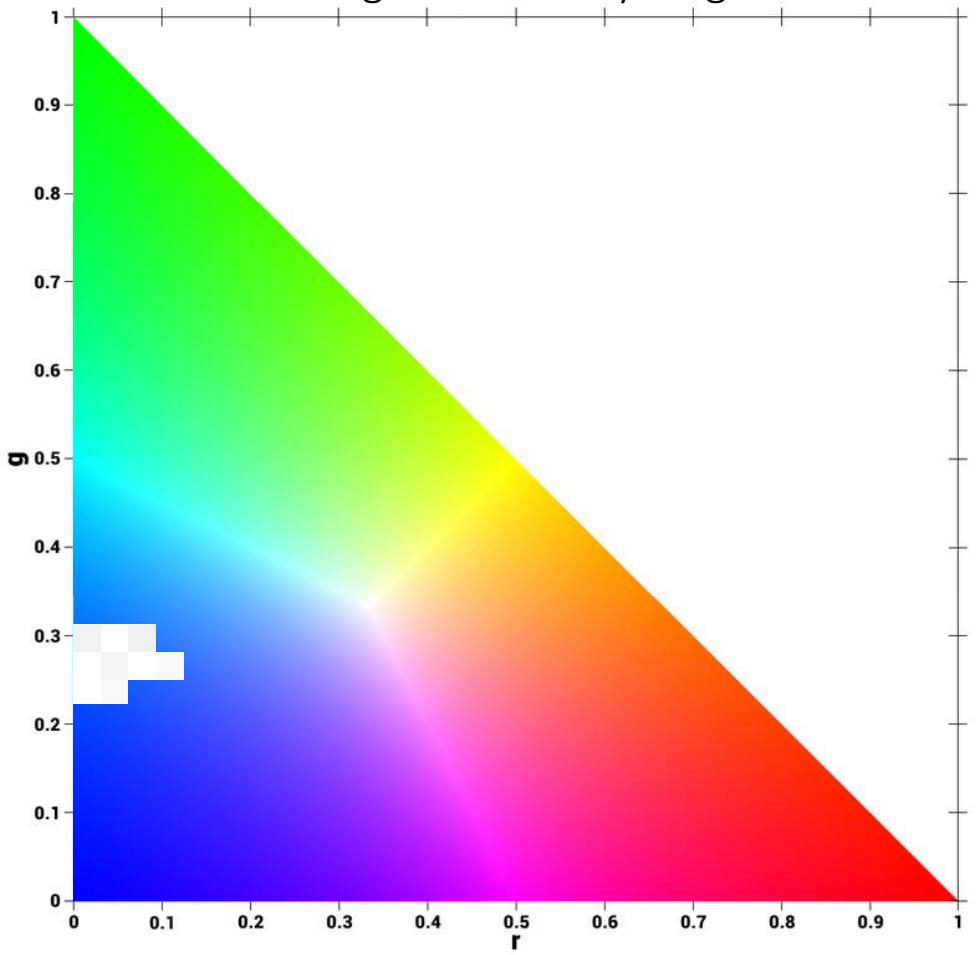
ROI

Side view blue

2d histogram image



Peak location of histogram (white blot)
in the rg chromaticity diagram



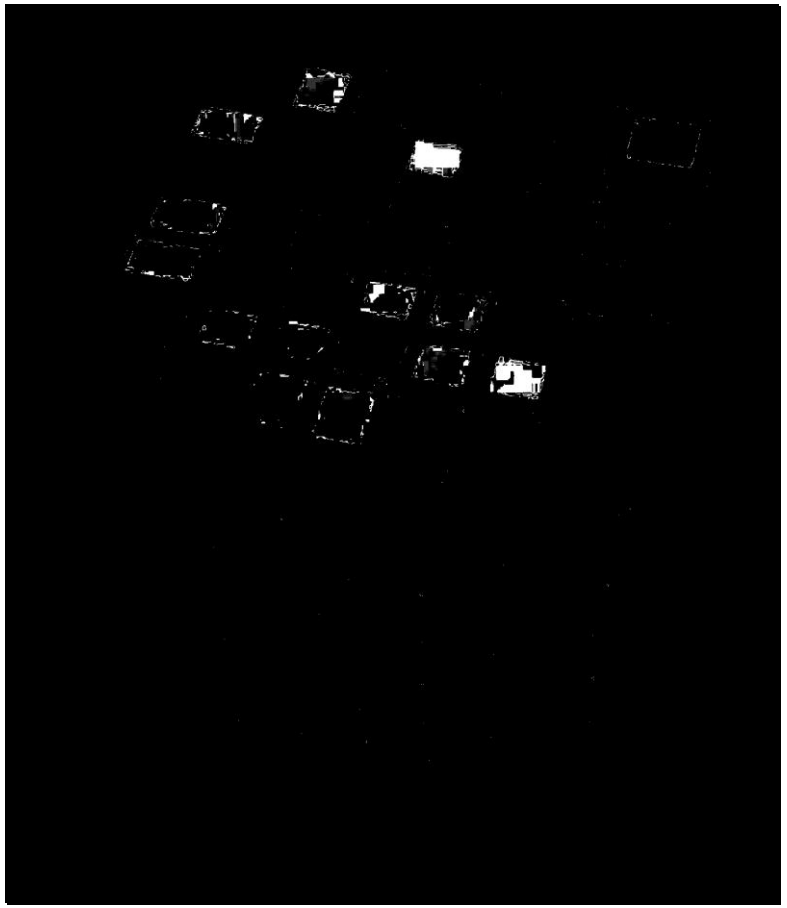
As shown, histogram peaks (white blot) used in segmentation correspond to the blue area of the rg chromaticty diagram.

ROI

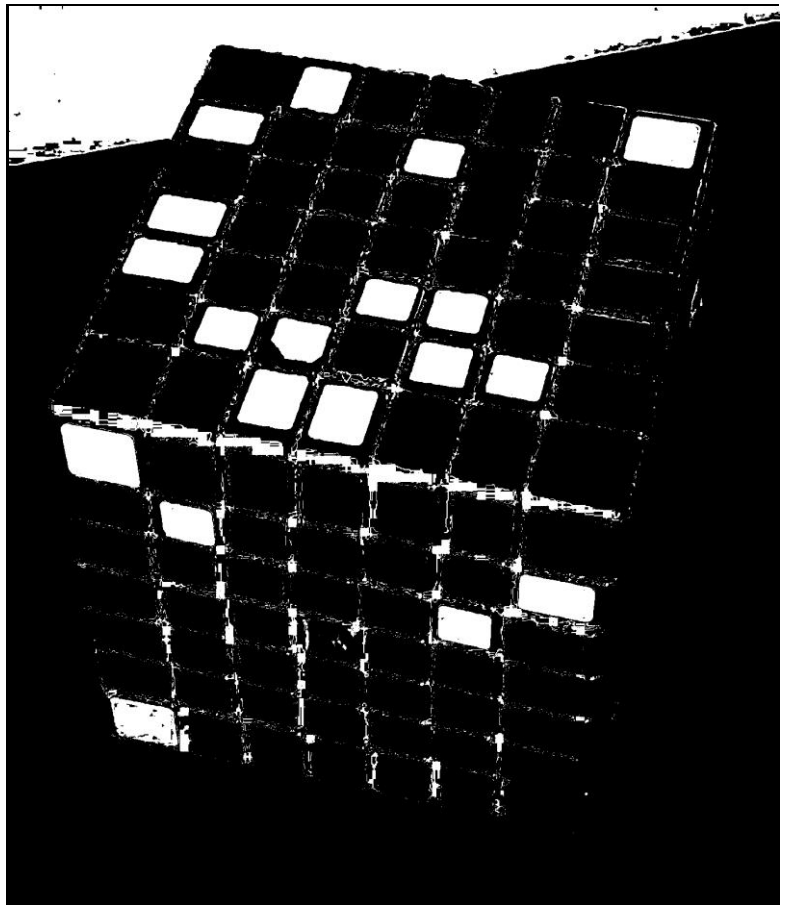
Top view white

Original Image

Parametric Segmentation



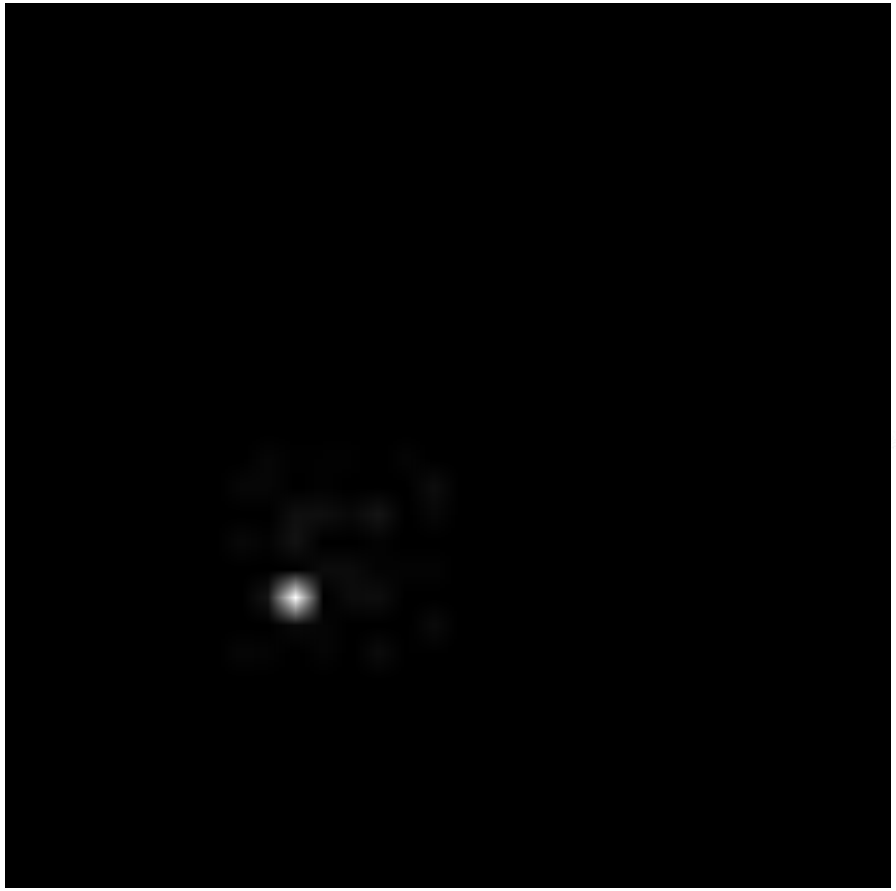
Nonparametric Segmentation



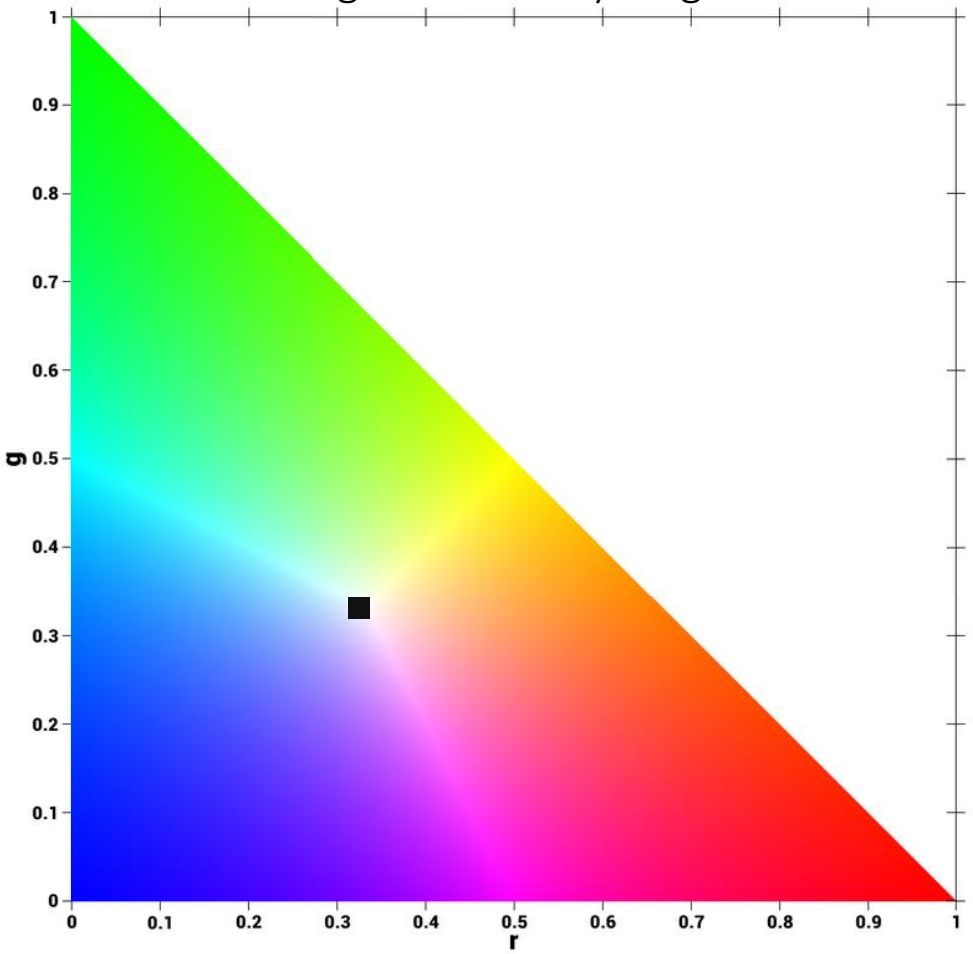
ROI

Top view white

2d histogram image



Peak location of histogram (black blot) in the rg chromaticity diagram



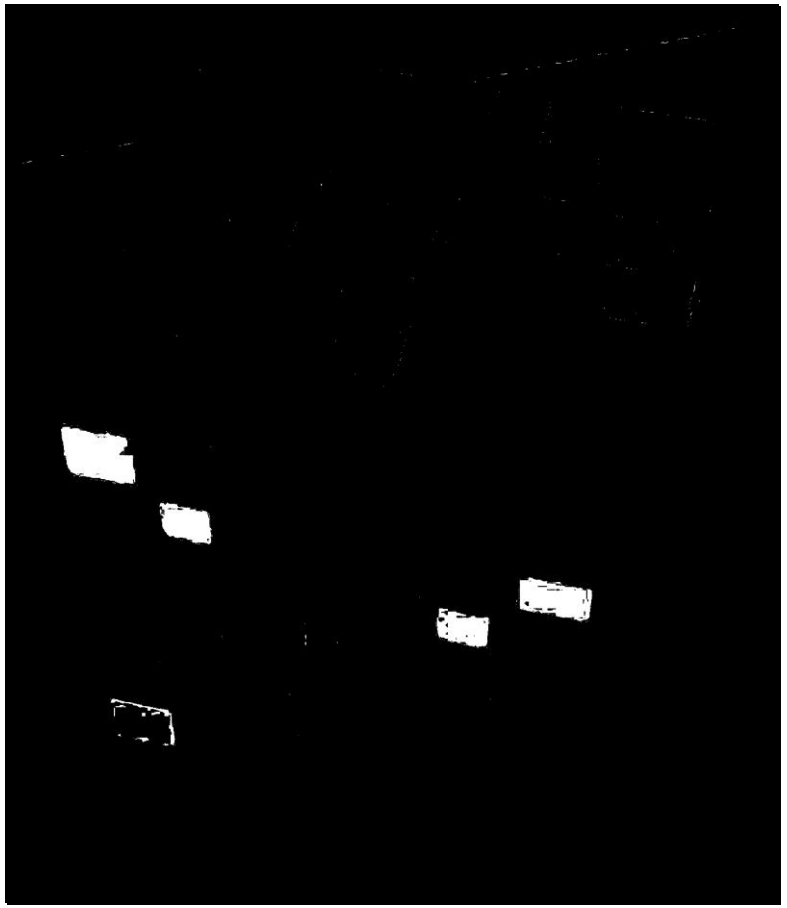
As shown, histogram peaks (black blot) used in segmentation correspond to the white area of the rg chromaticty diagram.

ROI

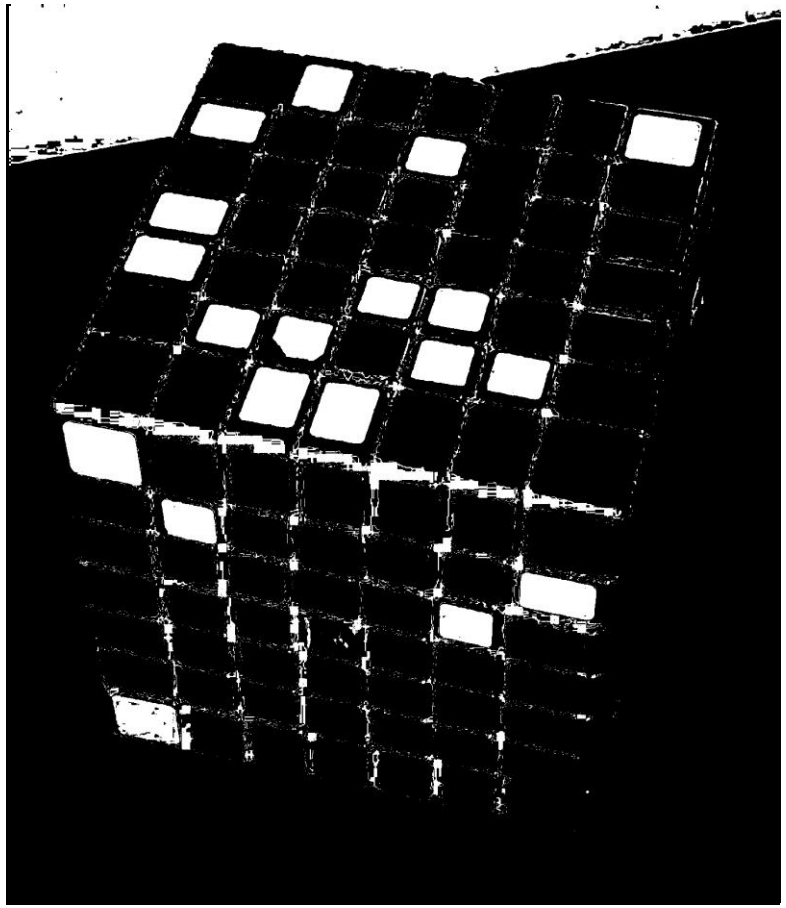
Side view white

Original Image

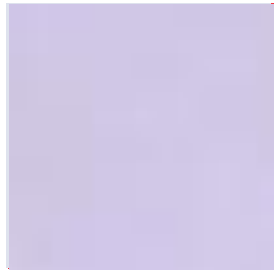
Parametric Segmentation



Nonparametric Segmentation

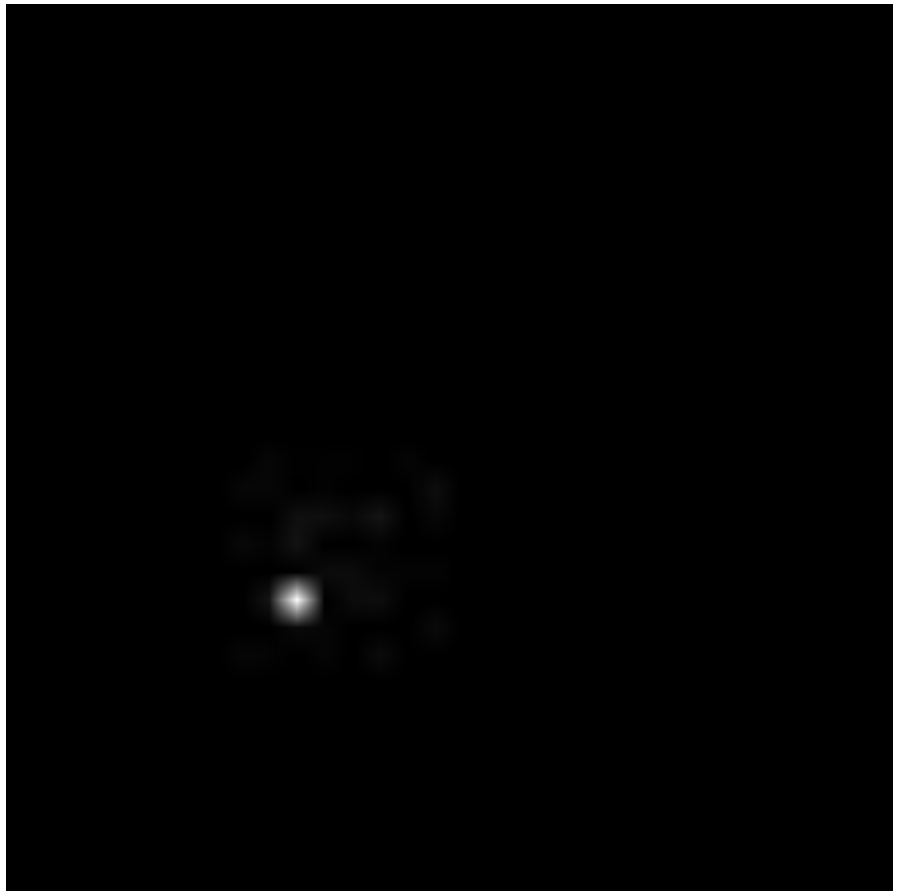


ROI

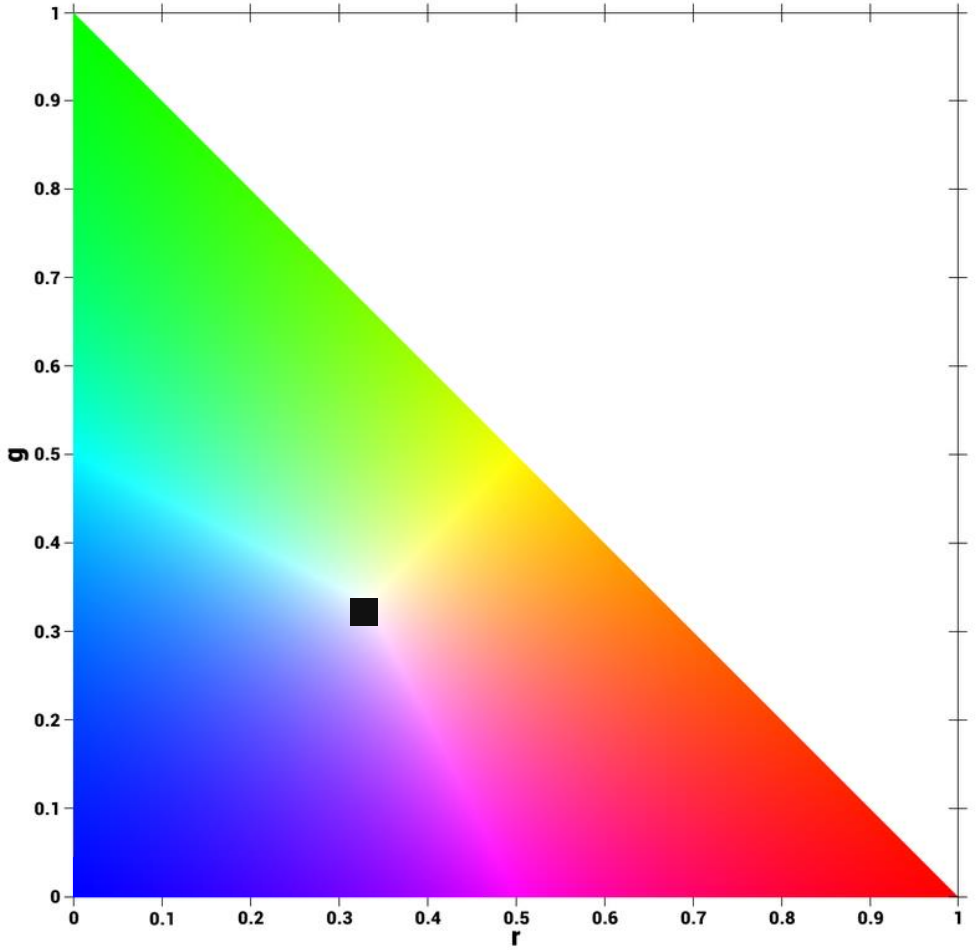


Side view white

2d histogram image



Peak location of histogram (black blot) in the rg chromaticity diagram



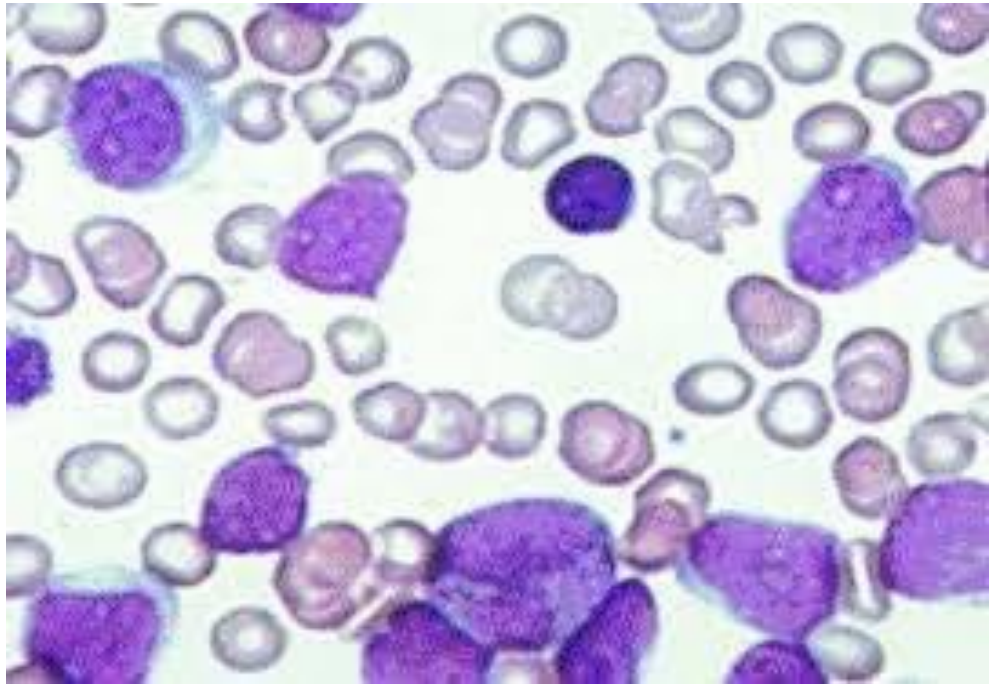
As shown, histogram peaks (black blot) used in segmentation correspond to the white area of the rg chromaticty diagram.

Analysis:

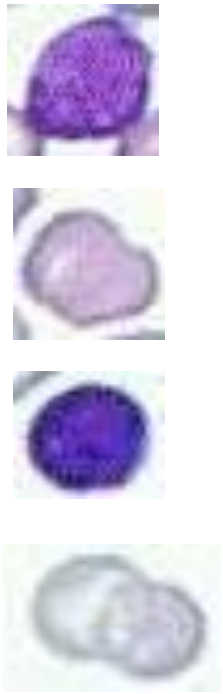
- Not all the regions with the color distribution of interest were captured for all images and for both techniques.
- There were captured regions that were not predicted to have the color distribution of interest (see side view red comparison). These unintended parts may really belong in the ROI. However, our eyes cannot detect them properly.
- Using non-parametric segmentation results to more of the unintended parts of the image to be detected. Hence, the parametric technique is sometimes smoother and cleaner (see side view blue comparison).
- Non-parametric segmentation captures a larger area of the intended parts of the image compared to the parametric segmentation (see side view yellow comparison).

Further Investigation: Color segmentation of image of cancer cells

Original Image



Cell Image

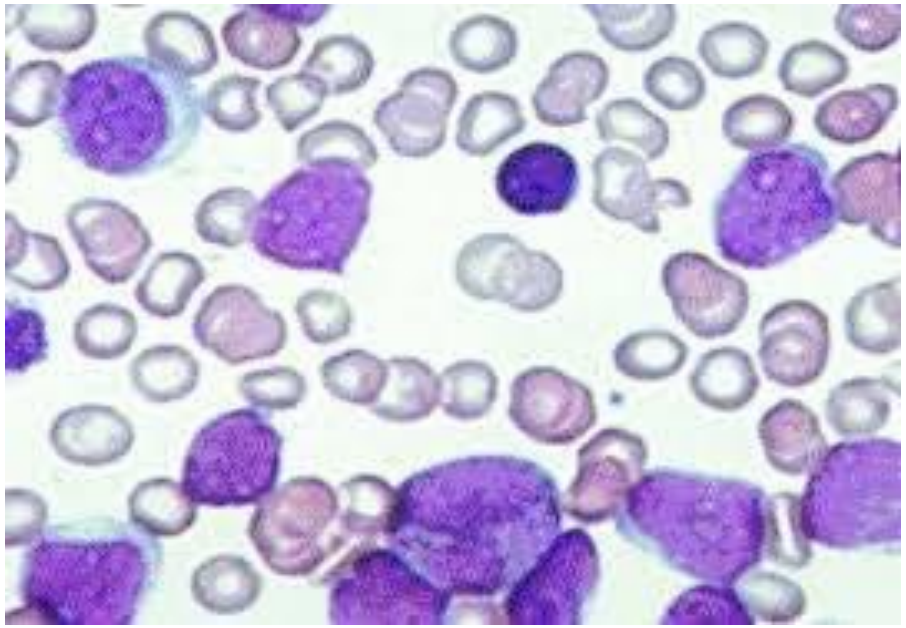


ROI

Cell Image

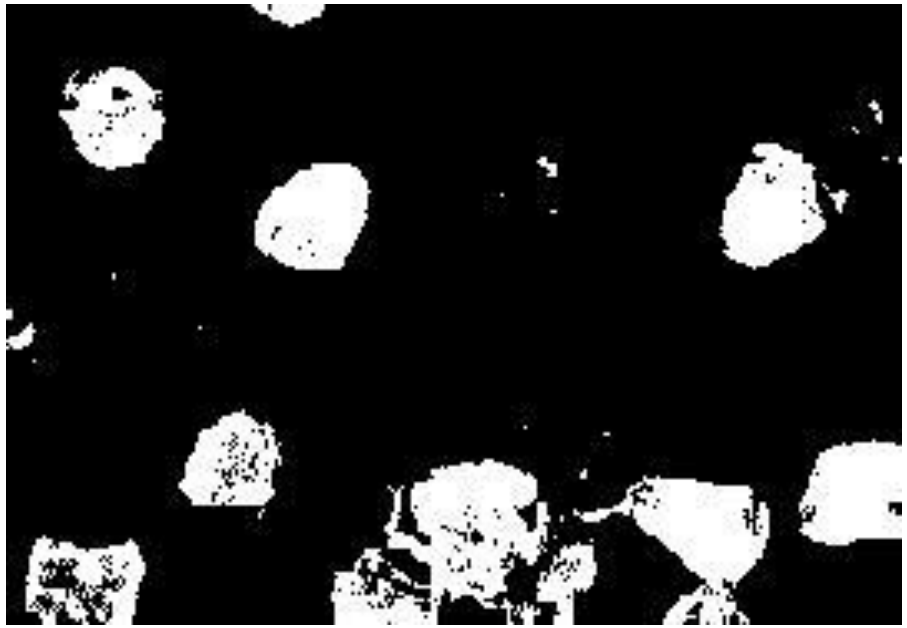
ROI

Original Image



Parametric Segmentation

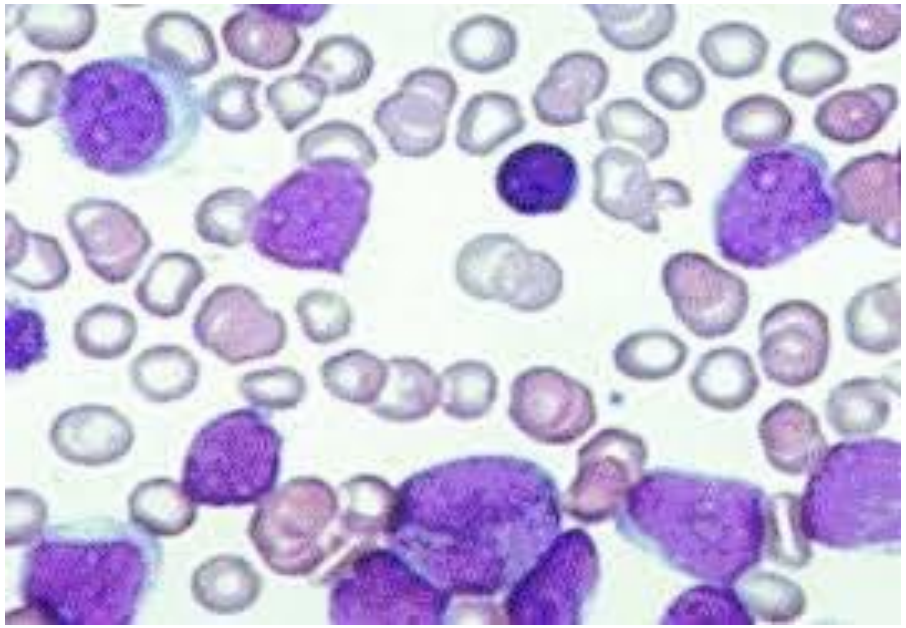
Nonparametric Segmentation



Cell Image

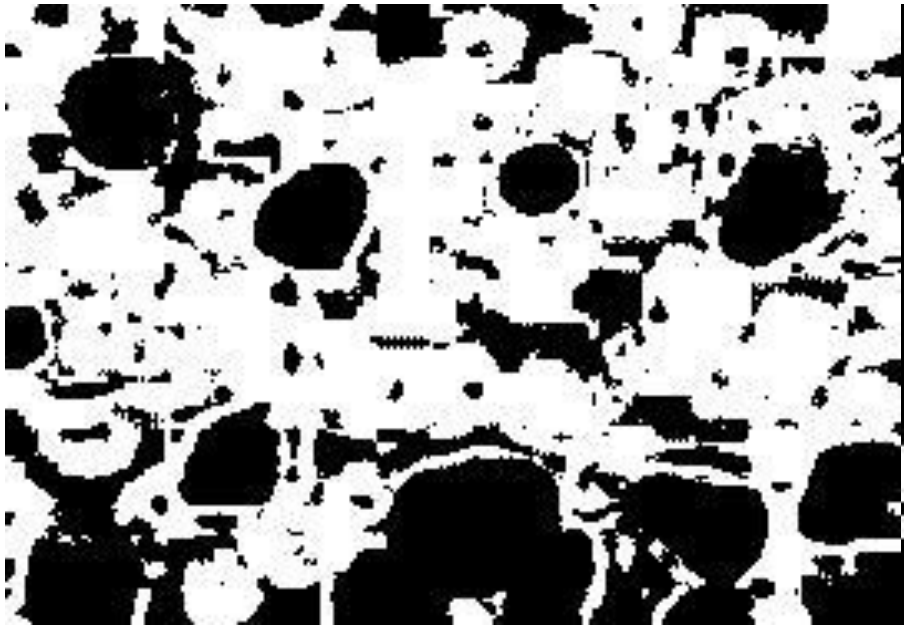
ROI

Original Image



Parametric Segmentation

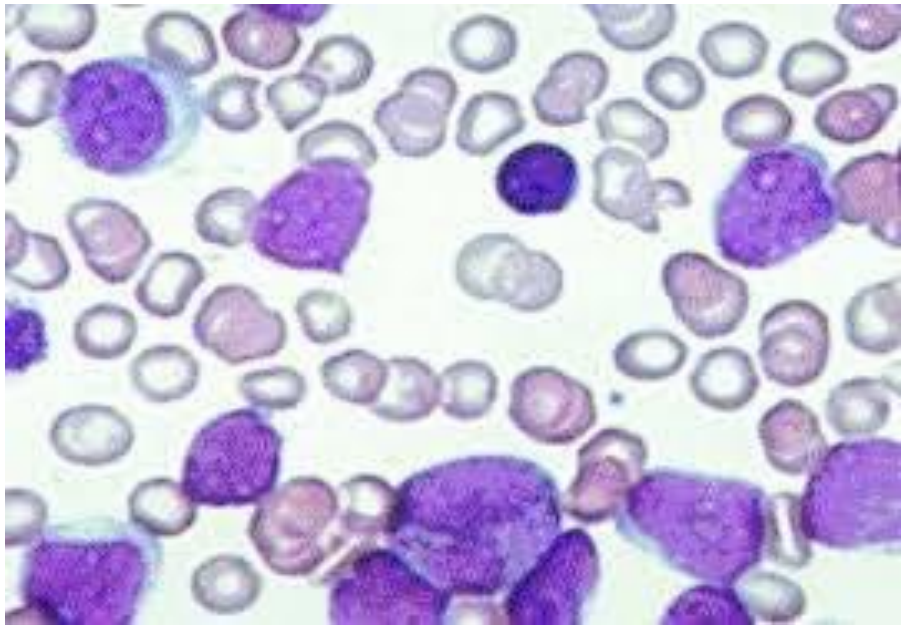
Nonparametric Segmentation



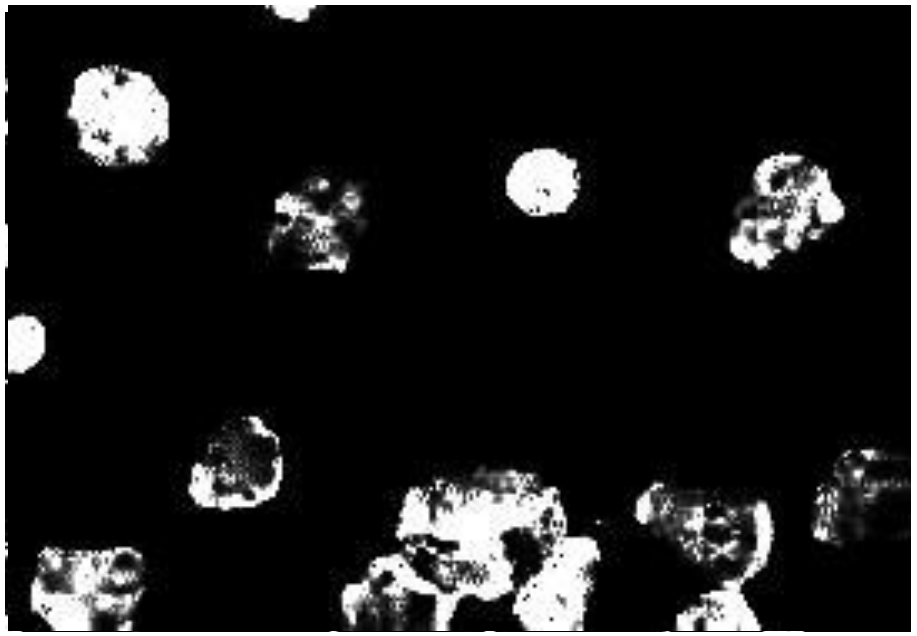
Cell Image

ROI

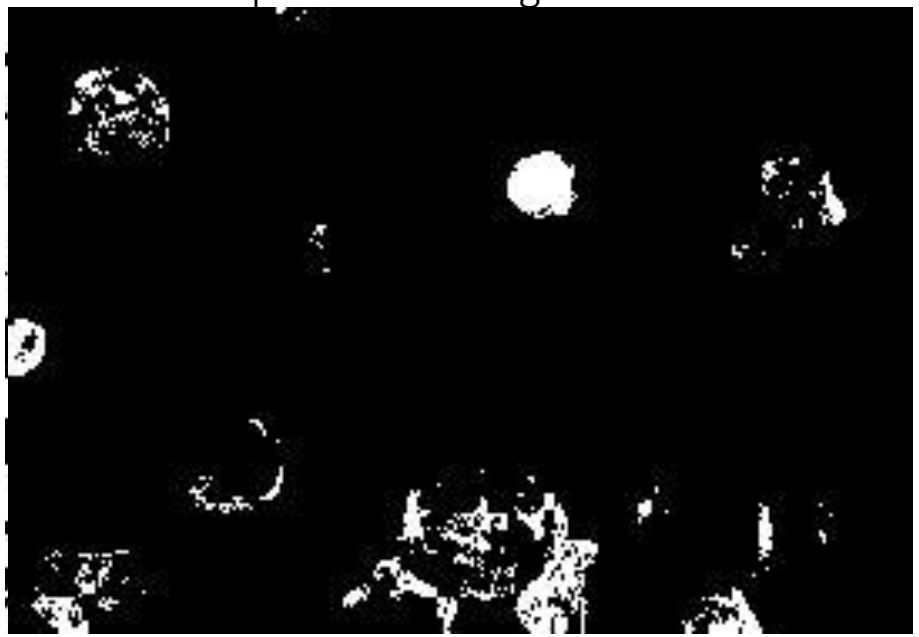
Original Image



Parametric Segmentation



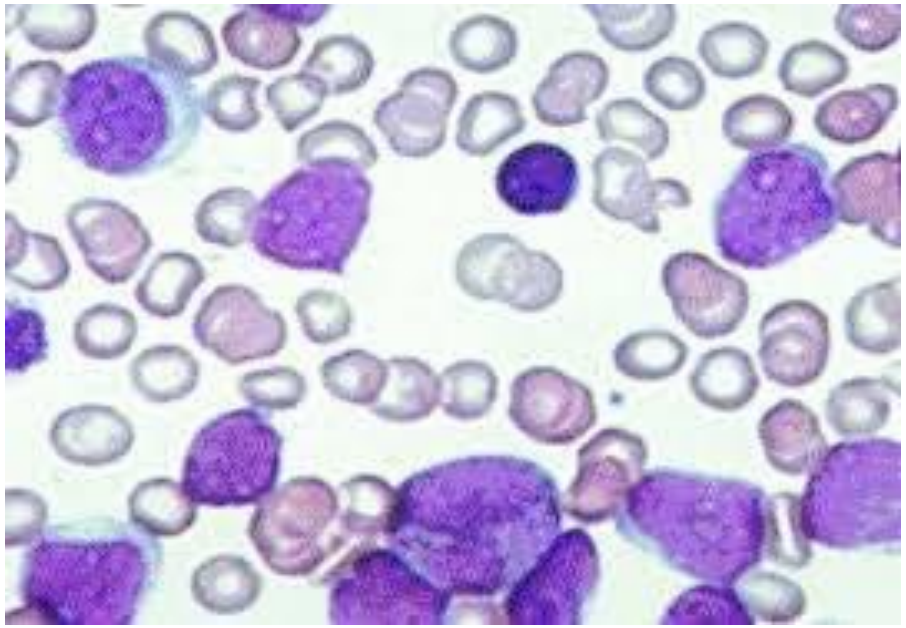
Nonparametric Segmentation



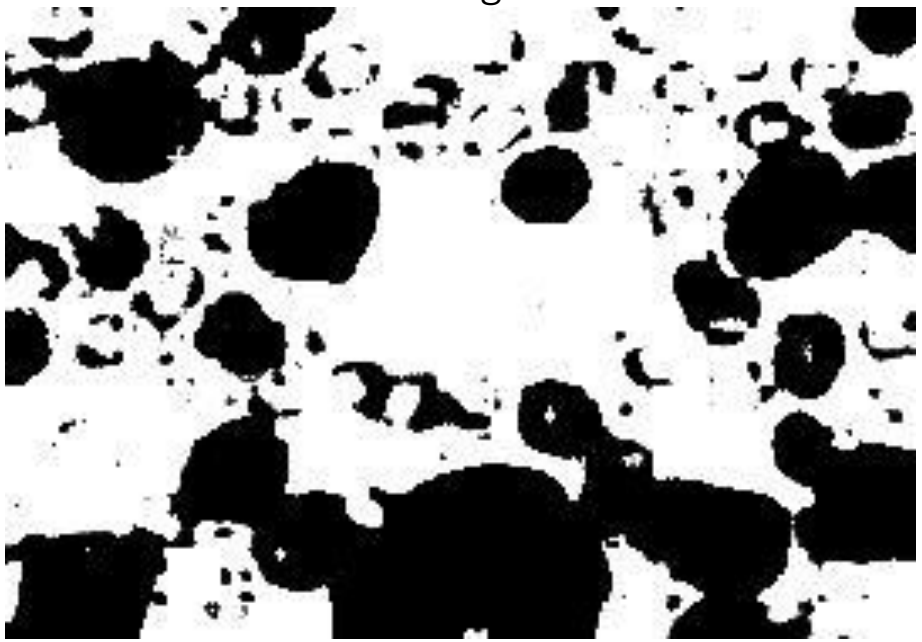
Cell Image

ROI

Original Image

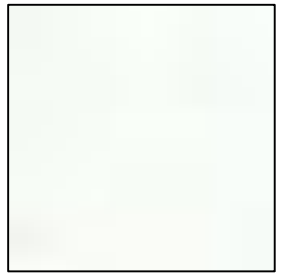


Parametric Segmentation

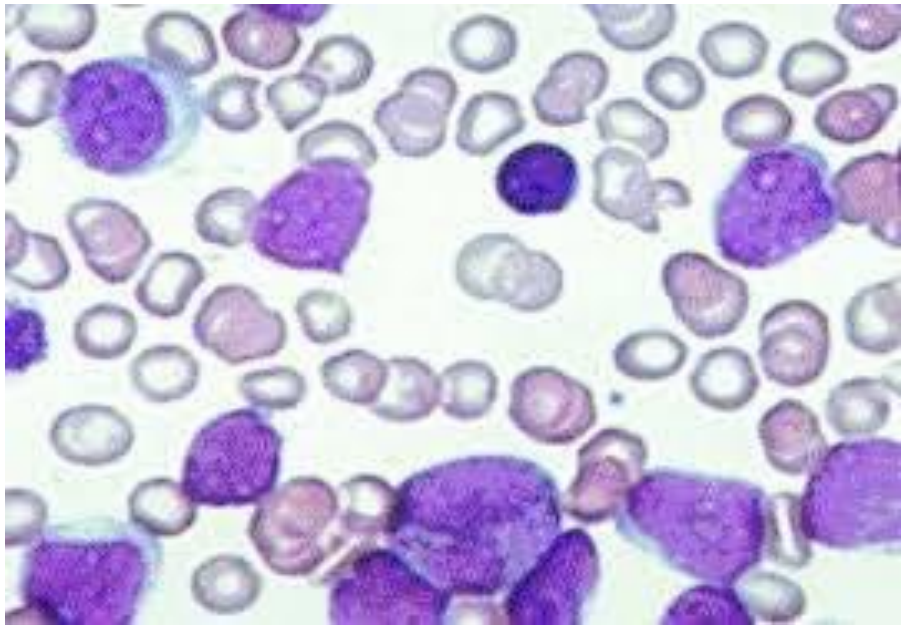


Nonparametric Segmentation

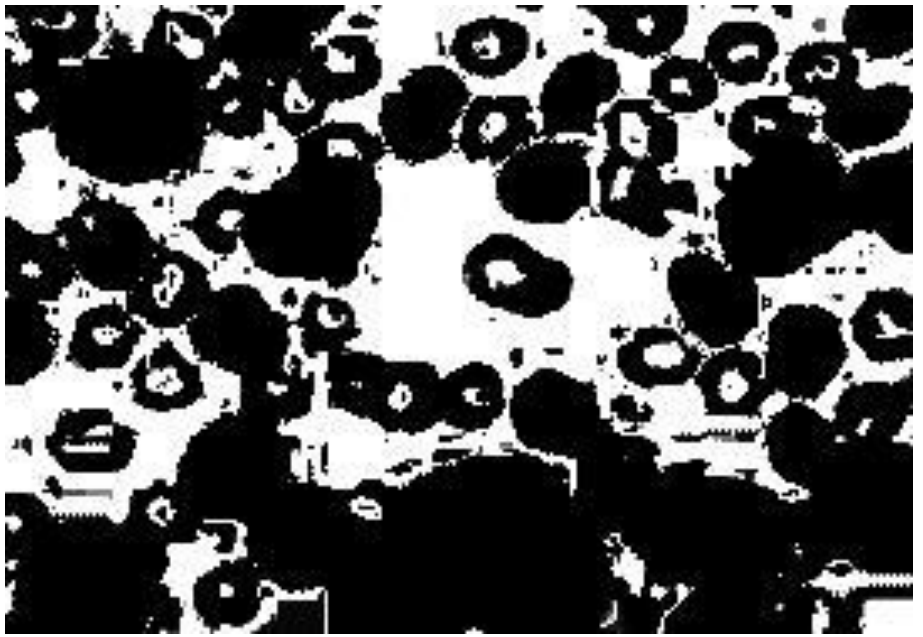
ROI



Original Image



Parametric Segmentation



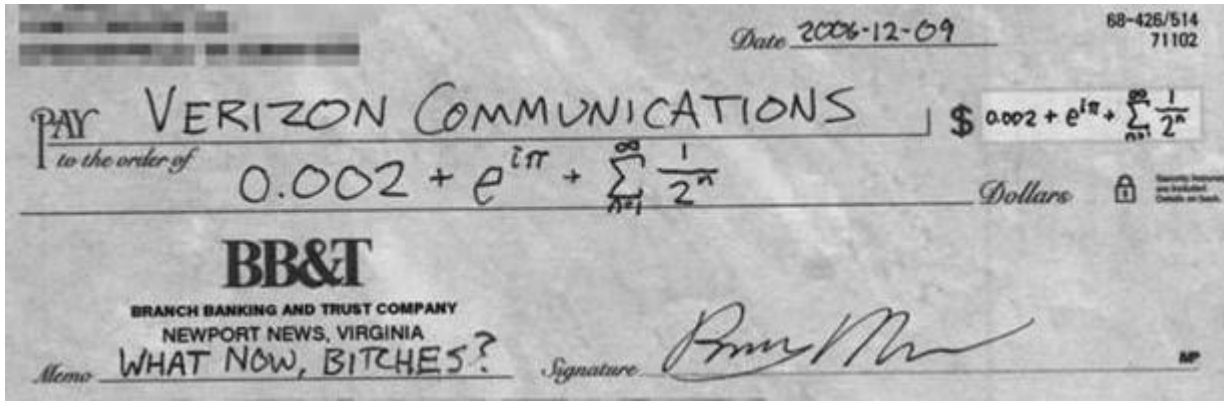
Nonparametric Segmentation

Further Investigation: Grayscale Image Segmentation

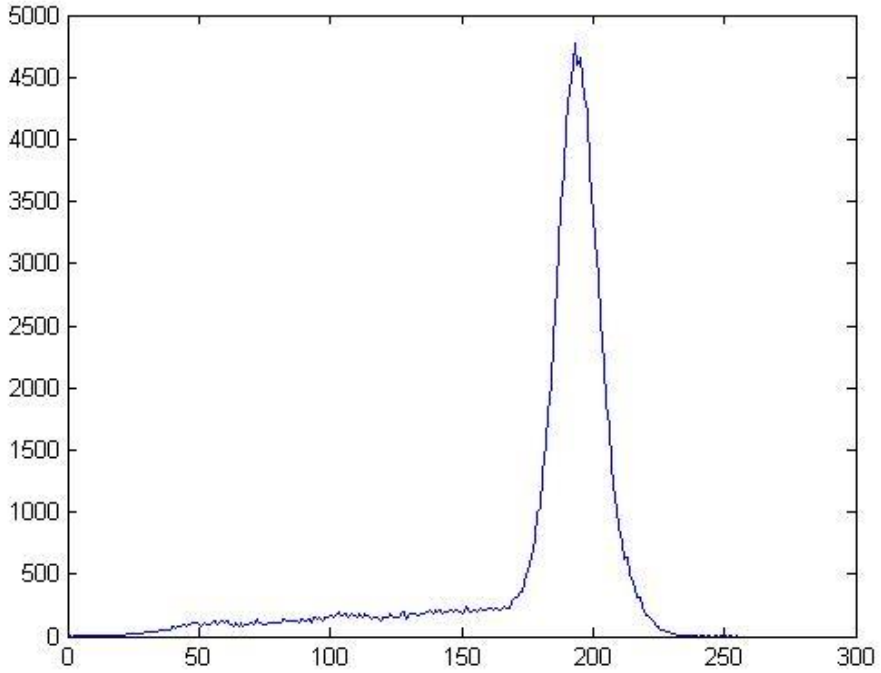
This can be done by thresholding if the image has a distinct grayscale range from the background. An example of such image is the check below, where its histogram has a large peak that corresponds to its background pixels.

```
I = imread('check.jpg');
[count,cells] = imhist(I, 256);
a = plot(cells,count);
BW = I<125;
imshow(BW);
```

Original Image



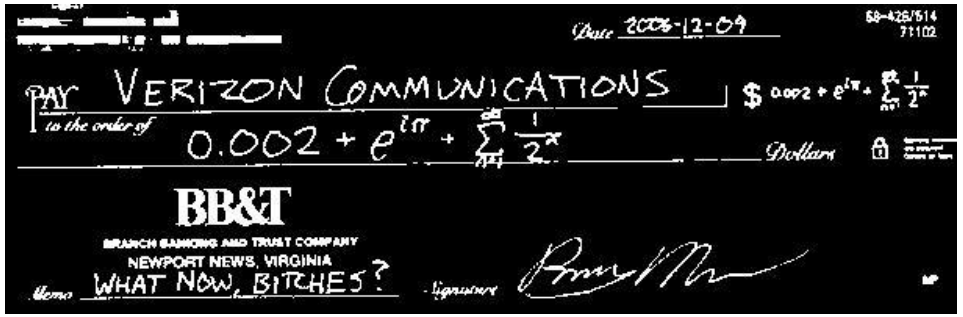
Histogram
(grayscale vs pixels)



Further Investigation: Grayscale Image Segmentation

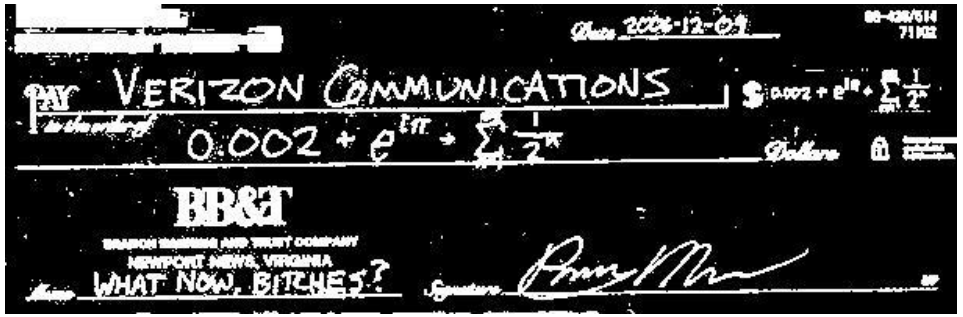
I < 25

I < 125



I < 75

I < 175



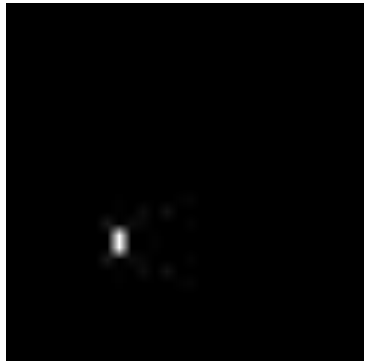
If we want to pick out the text from the background, we need to set a threshold such that the background pixels are excluded while the text pixels are retained. We can use the image histogram as reference. As shown, for I<25, the threshold is too low and so, most text pixels were not captured. As for I<175, the threshold is higher than desired, resulting to the detection of some background pixels. For me, the most appropriate threshold is I<125.

Further Investigation: Effect of number of bins to image segmented by nonparametric estimation

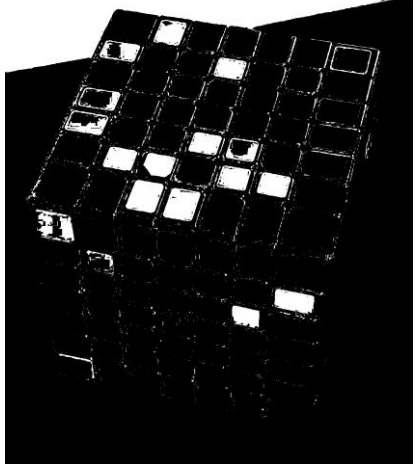
ROI

Orig Image

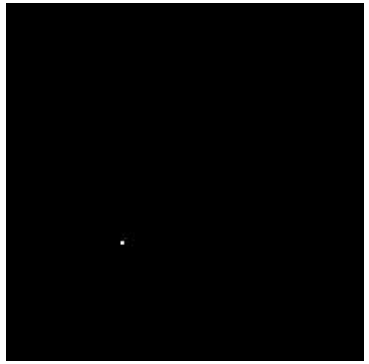
Bin no.: 30
2d Histogram



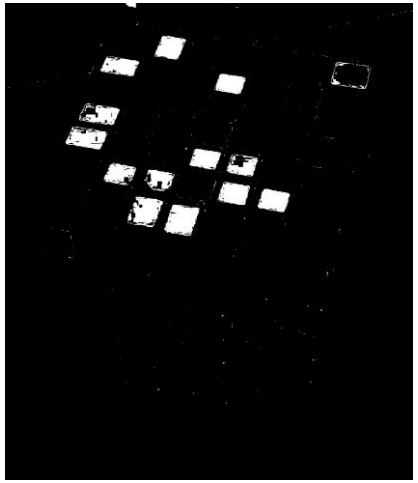
Segmented Image



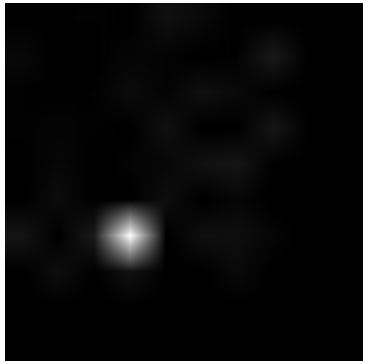
Bin no.: 200
2d Histogram



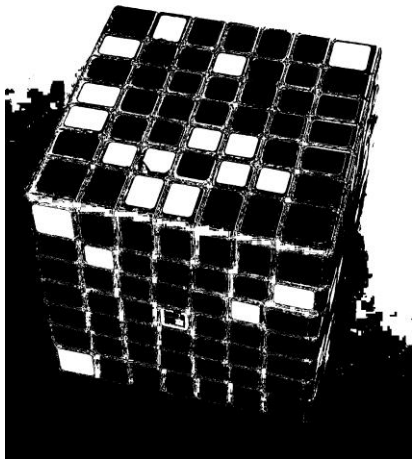
Segmented Image



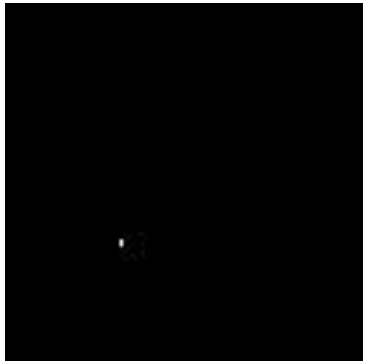
Bin no.: 10
2d Histogram



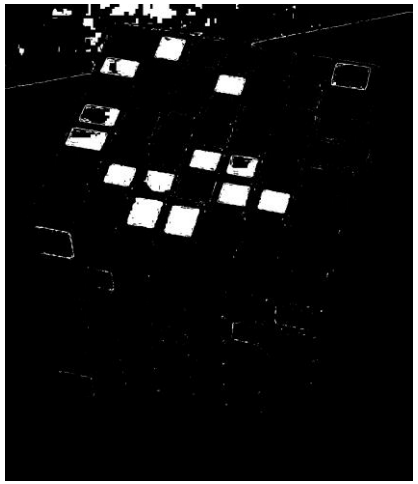
Segmented Image



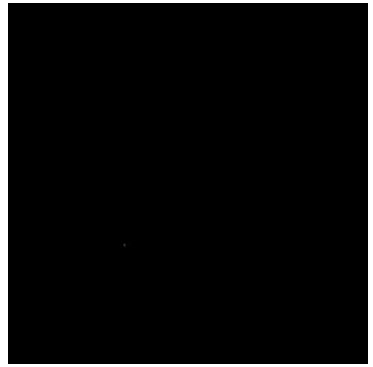
Bin no.: 100
2d Histogram



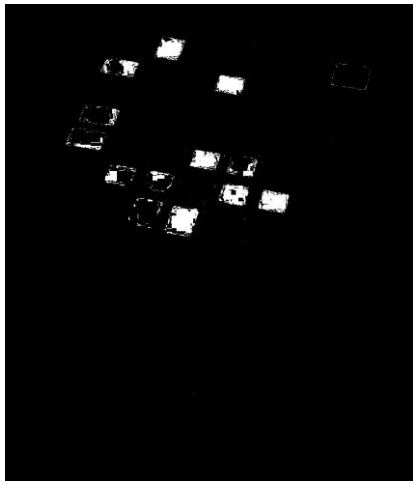
Segmented Image



Bin no.: 1000
2d Histogram



Segmented Image



Analysis:

- Larger bin number results to finer histograms.
- Finer histogram results to a more defined region of the rg chromaticity diagram that can be covered.
- Smaller region covered in the chromaticity diagram results to less matches in the detected areas.

Self-evaluation: 12/10