Generating Two Dimensional Log Chroma Histogram from Raw Sensor Data

Siddhant Sahu, Jean Baptiste Thomas, Jon Yngve Hardeberg

Norwegian Colour and Visual Computing Lab, Norwegian University of Science and Technology, Gjovik, Norway

```
clear, clc;
```

Enter the filename and the Bayer pixel arrangement of camera,

'rggb','bggr','gbrg' or 'grbg' - -

```
filename = 'right_lamp.dng';
bayer_type = 'rggb';
```

Define transformation matrix from sRGB space to XYZ space for later use

```
srgb2xyz = [0.4124564 0.3575761 0.1804375;
    0.2126729 0.7151522 0.0721750;
    0.0193339 0.1191920 0.9503041];
```

Reading DNG file from Adobe RAW to DNG Converter output

```
warning off MATLAB:tifflib:TIFFReadDirectory:libraryWarning
t = Tiff(filename,'r');
```

```
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 37393 (0x9211) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50931 (0xc6f3) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50932 (0xc6f4) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50936 (0xc6f8) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50941 (0xc6fd) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50942 (0xc6fe) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50964 (0xc714) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50965 (0xc715) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50966 (0xc716) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50967 (0xc717) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50969 (0xc719) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50970 (0xc71a) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 50971 (0xc71b) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 51041 (0xc761) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 51111 (0xc7a7) encountered.'
```

```
offsets = getTag(t,'SubIFD');
setSubDirectory(t,offsets(1));
```

```
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 33421 (0x828d) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 33422 (0x828e) encountered.'
Warning: TIFF library warning - 'TIFFReadDirectory:  Unknown field with tag 51041 (0xc761) encountered.'
```

```
raw = read(t);
close(t);
meta_info = imfinfo(filename);
```

```
x_origin = meta_info.SubIFDs{1}.ActiveArea(2)+1;
width = meta_info.SubIFDs{1}.DefaultCropSize(1);
y_origin = meta_info.SubIFDs{1}.ActiveArea(1)+1;
height = meta_info.SubIFDs{1}.DefaultCropSize(2);
raw = double(raw(y_origin:y_origin+height-1,x_origin:x_origin+width-1));
```

Linearize

```
if isfield(meta_info.SubIFDs{1},'LinearizationTable')
    ltab=meta_info.SubIFDs{1}.LinearizationTable;
    raw = ltab(raw+1);
end
black = meta_info.SubIFDs{1}.BlackLevel(1);
saturation = meta_info.SubIFDs{1}.WhiteLevel;
lin_bayer = (raw-black)/(saturation-black);
lin_bayer = max(0,min(lin_bayer,1));
clear raw
```

Camera's Auto White Balance

```
wb_multipliers = (meta_info.AsShotNeutral).^-1;
wb_multipliers = wb_multipliers/wb_multipliers(2);
mask = wbmask(height,width,wb_multipliers,bayer_type);
balanced_bayer = lin_bayer .* mask;
%clear lin_bayer mask
```

Colour Correction Matrix from DNG Info

```
temp = meta_info.ColorMatrix2;
xyz2cam = reshape(temp,3,3)';
```

Demosaicing

```
temp = uint16(lin_bayer/max(lin_bayer(:))*2^16);
lin_rgb = single(demosaic(temp,bayer_type))/65535;
clear balanced_bayer temp
```

Manual White Balance from Colour Checker

```
illu_x = 754;
illu_y = 1997;
light_color = [lin_rgb(illu_x,illu_y,1), lin_rgb(illu_x,illu_y,2), lin_rgb(illu_x,illu_y,3)];
wb_mul = (light_color(:)/light_color(2)).^-1;
wb_ccm = [wb_mul(1) 0 0;
    0 wb_mul(2) 0;
    0 0 wb_mul(3)];
balanced_lin_bayer = apply_cmatrix(lin_rgb, wb_ccm);
balanced_lin_bayer = max(0,min(balanced_lin_bayer,1));
```

For Viewing Purpose

Colour Space Conversion

```
rgb2cam = xyz2cam * srgb2xyz;
rgb2cam = rgb2cam ./ repmat(sum(rgb2cam,2),1,3);
cam2rgb = rgb2cam^-1;

lin_srgb = apply_cmatrix(balanced_lin_bayer,cam2rgb);
lin_srgb = max(0,min(lin_srgb,1));
```

Brightness and Gamma

```
grayim = rgb2gray(lin_srgb);
grayscale = 0.25/mean(grayim(:));
bright_srgb = min(1,lin_srgb*grayscale);
clear lin_srgb grayim
```

Display and Save

```
nl_srgb = bright_srgb.^(1/2.2);

f1 = figure(1);
imshow(nl_srgb);
saveas(f1, 'right_lamp.png');
```

Generate Log Chroma Histogram

The log chroma histogram has two dimension *u* and *v* which are defined as follows,

$u^{(k)} = log(I_g^{(k)}/I_r^{(k)})$ and $v(k) = log(I_g^{(k)}/I_b^{(k)})$

where *k* is the particular pixel and I_r, I_g, I_b are its corresponding red, green and blue values.

```
uv_0 = -1.421875;
bin_size = 1 / 64;
bin_num = 256;

[h, w, ~] = size(balanced_lin_bayer);
I_log = log(single(balanced_lin_bayer)); %all values of I_log = -ve as lin_rgb 0<-1
u = I_log(:, :, 2) - I_log(:, :, 1); %mix of +ve and -ve values mosty between 0 and 1
v = I_log(:, :, 2) - I_log(:, :, 3);

% calculate mask
valid = ~isinf(u) & ~isinf(v) & ~isnan(u) & ~isnan(v);

hist = zeros(256, 256); %initializing the histogram
% iterating over the entire image and plot the log chroma histogram
for i = 1:h
    for j = 1:w
        if (valid(i, j))
            u_val = round((u(i, j) - uv_0) / bin_size);
            v_val = round((v(i, j) - uv_0) / bin_size);
            u_val = max(min(u_val, 256), 1);
            v_val = max(min(v_val, 256), 1); %after this we know which bin to in
            hist(u_val, v_val) = hist(u_val, v_val) + 1;
        end
    end
end
hist = hist / max(eps, sum(hist(:))); %normalize of hist
```

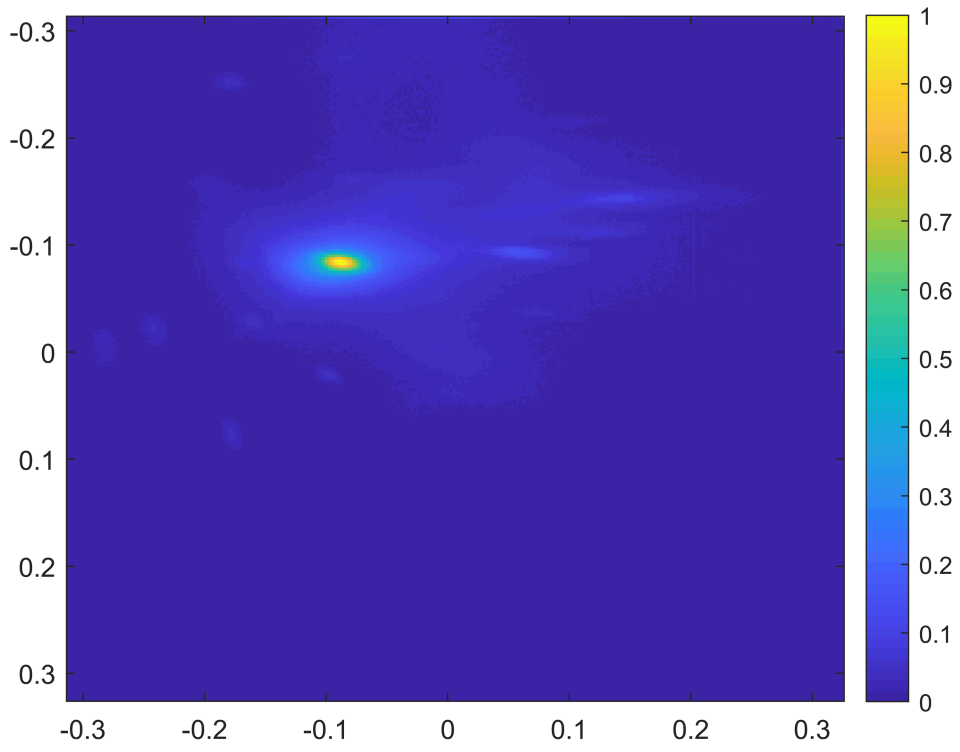
Visualize the Histogram

eq 8 in CCC Paper, normalize histogram

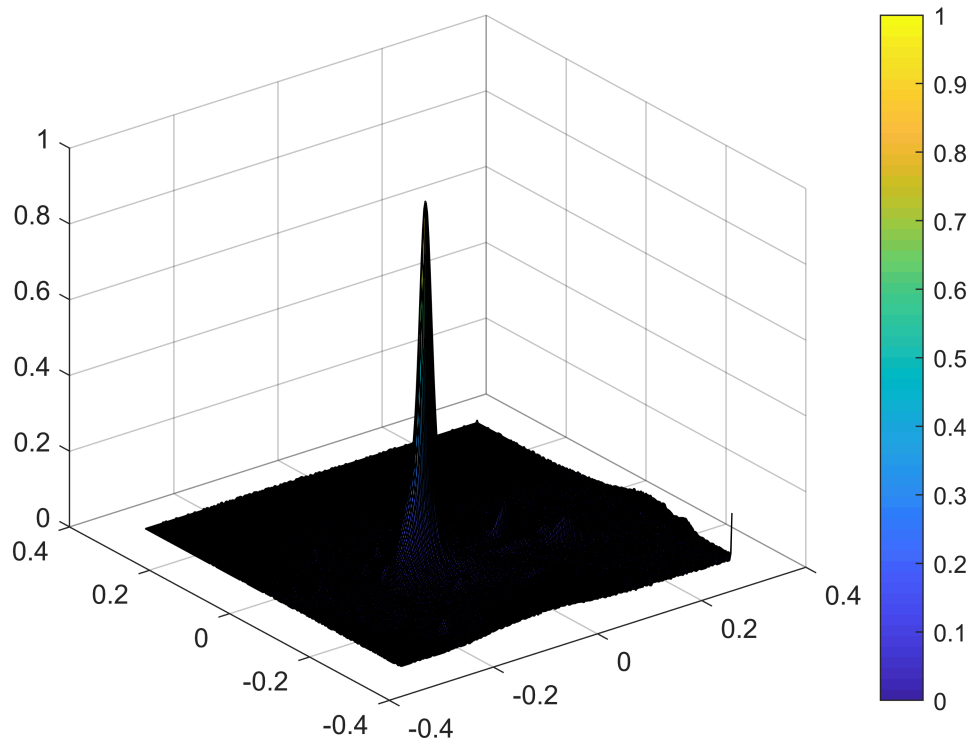
```
if ~exist('rho', 'var')
  rho = 0.5;
end

if any(hist(:) < 0)
  max_val = max(max(abs(hist), [], 1), [], 2);
  hist = bsxfun(@rdivide, hist, max_val);
  hist = sign(hist) .* (abs(hist).^rho);
  hist = (hist + 1) / 2;
else
  hist = bsxfun(@rdivide, hist, max(max(hist, [], 1), [], 2));
  hist = hist.^rho;
end
```

Plot and Save Histogram

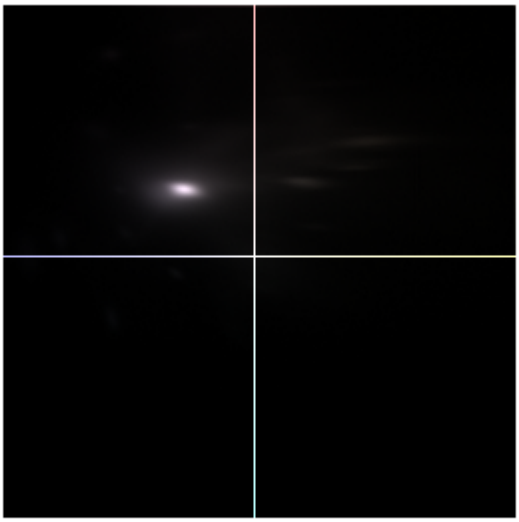
```
bins_num = 256;
bins = -0.3125 + [0 : 0.0025 ...
  : (0.0025 * (bins_num - 1))];

assert(length(bins) == size(hist,1))
assert(length(bins) == size(hist,2))

[u_hisi, v_hisi] = ndgrid(bins, bins);
log_rgb = cat(3, -u_hisi, zeros(size(u_hisi)), -v_hisi);
rgb = exp(bsxfun(@minus, log_rgb, max(log_rgb, [], 3))); %to create the color square or color w
rgb = bsxfun(@rdivide, rgb, max(rgb,[],3));

f2 = figure(2);
imagesc(bins, bins, hist);
colorbar;
saveas(f2, 'rightlamp_imagesc.png');
```




```
f3 = figure(3);
surf(bins, bins, hist);
colorbar;
saveas(f3, 'rightlamp_surf.png');
```




```
% finding the zero bin index to draw the axis
zero_bin_idx = find(bins == 0);
if (numel(zero_bin_idx) >= 1)
  assert(numel(zero_bin_idx) == 1);
  hist(zero_bin_idx,:,:) = 1;
  hist(:,zero_bin_idx,:) = 1;
end


V = {};
for c = 1:size(hist,3)
  V{c} = bsxfun(@times, hist(:,:,c), rgb);
  if c < size(hist,3)
    V{c} = padarray(V{c}, [2,0], 1, 'post');
  end
end
V = cat(1, V{:});

f4 = figure(4);
imshow(V);
saveas(f4, 'rightlamp_log.png');
```



References

- "Convolutional Color Constancy" *Barron* (ICCV 2015) [Suplementary] [Video]
- "Fast Fourier Color Constancy" *Barron et al.* (CVPR 2017) [Code] [Suplementary] [Video]
- "FC4: Fully Convolutional Color Constancy with Confidence-weighted Pooling" *Hu et al.* (CVPR 2017) [Code]
- "Single and Multiple Illuminant Estimation Using Convolutional Neural Networks" *Bianco et al.* (TIP 2017)
- "Recurrent Color Constancy" *Qian et al.* (ICCV 2017) [Code]
- "Two Illuminant Estimation and User Correction Prefernece" *Cheng et al.* (CVPR 2016) [Webpage]
- "Deep Specialized Network for Illuminant Estimation" *Shi et al.* (ECCV 2016) [Code] [Suplementary] [Webpage]
- "Color Constancy by Deep Learning" *Lou et al.* (BMVC 2015)
- "Color Constancy using CNNs" *Bianco et al.* (CVPR 2015)
- "Effective Learning-Based Illuminant Estimation Using Simple Features" *Cheng at al.* (CVPR 2015) [Code] [Suplementary] [Webpage]
- "Computational Color Constancy: Survey and Experiments" (TIP 2011)
- Color Constancy Marc Ebner
- https://ipg.fer.hr/ipg/resources/color_constancy