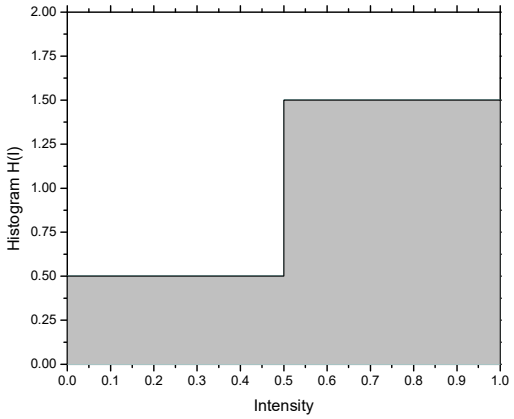
Video Signals

Date: 6 February 2023

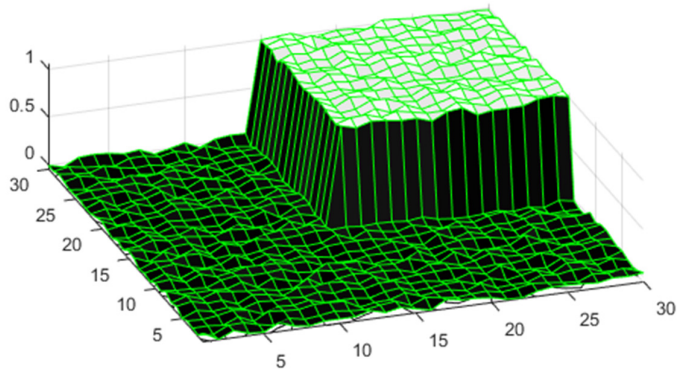
Ex.1.[11 pts] Assuming a continuous distribution of intensity values for a gray scale image in the range 0-1 with the following (continuous) normalized histogram:



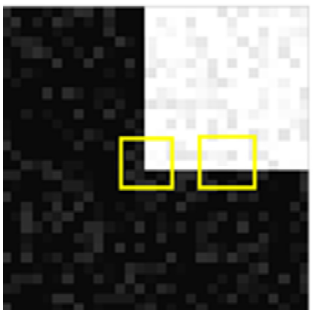
$$H(I) = \begin{cases} 1/2 & \text{for } 0 \le I < 0.5 \\ 3/2 & \text{for } 0.5 \le I \le 1 \end{cases}$$

Provide the equalization function in order to obtain a flat normalized histogram.
(Normalized means that its integral over the whole range is equal to 1).

Ex.1.[11 pts] A gray scale image has a size of 30x30 pixels, black pixels have a value of “0” while white ones a value of “1”. A small random noise is added to each pixel and the intensities are depicted below.



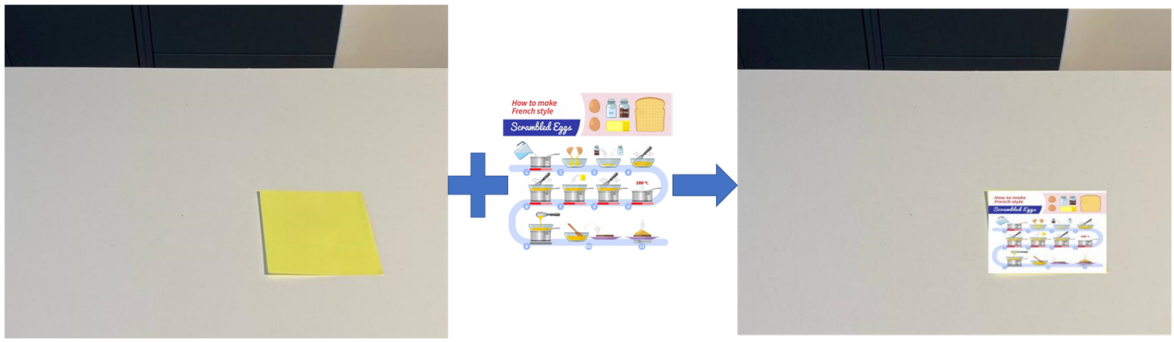
Propose a possible 5x5 bilateral filter that can be used to reduce noise preserving edges, in particular propose a possible set of filter values for the two regions below.



Ex. 3 is overleaf

Es.3. [11 pts to be solved writing on the paper a suitable MATLAB code]

You have to develop a simple augmented relity application for cooking assistance that visualize a recipe image over a colored marker in the original input image



Input image Recipe image Output image

Write a MATLAB script able to perform the following steps:

a) Read the color input image (stored in the file *'input.jpg'*) and visualize it.
b) Convert the input image into the HSV color space and extract the hue and saturation information.
c) Given a saturation threshold of 0.5 and a hue range centered around value 0.15 with a width of 0.04, create a binary mask assign true values to pixels having a hue value in the defined range and a saturation value grater than the saturation threshold (i.e. the pixels related to the yellow marker).
d) Find the pixel coordinates of all the pixels having a true value in the mask and then calculate the top-left and bottom-right corners of the minimum rectangle containing this set of pixels. (hint: just use the maximum and minimum coordinate values).
e) Read the recipe image stored in file *'recipe.jpg'*.
f) Using the top-left and bottom-right coordinates found in d) calculate the size of the rectangle and resize the recipe image using the appropriate size.
g) Using the top-left and bottom-right coordinates substitute the yellow marker region with the resized recipe image. Visualize the output image.

List of possible Matlab functions

```
figure
im2double
imread
rgb2gray
rgb2hsv
find
imhist
imopen
rgb2ind
histeq
hist
imshow
fspecial
imerase
strel
imnoise
imresize
```

Solutions

Es.1

The transfer function $F(I)$ is the integral of the normalized histogram:

$$F(I)=\begin{cases}\displaystyle\int_0^I 1/2\,dI=\frac{I}{2} & \text{for } 0\le I<0.5\\ \displaystyle\int_{1/2}^I 3/2\,dI+\int_0^{1/2}1/2\,dI=\frac{3(I-1/2)}{2}+\frac{1}{4}=\frac{3}{2}I-\frac{1}{2} & \text{for } 0.5\le I\le 1\end{cases}$$

Es.2

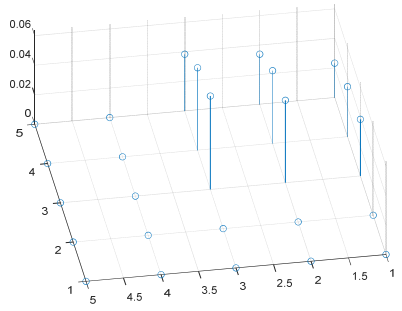
According to the Bilateral filter formulation we have:

$$H(\mathbf{p})=\frac{1}{W}\sum_{q\in S}G_\sigma\left(\|\mathbf{p}-\mathbf{q}\|\right)G_\sigma\left(\left|I_\mathbf{p}-I_\mathbf{q}\right|\right)I_\mathbf{q}$$

Where $\mathbf{p}$ are the coordinates of the considered point, S is the region over which the filter is applied (5x5 in this case), $\mathbf{q}$ are the coordinates of points in the region S, W is a weighting term to normalize the filter; G_σ is a gaussian function with standard deviation σ and $I_\mathbf{q}$ is the gray intensity in $\mathbf{q}$.

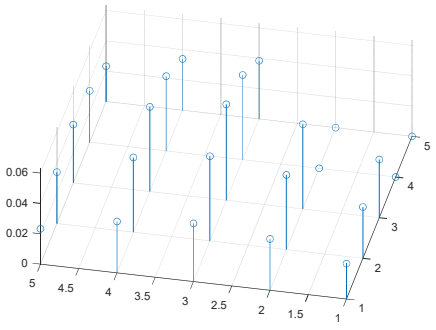
In the pixel closest to the corner belonging to the light region the filer would be something proportional to ($\sigma=2$):

0.000	0.000	0.038	0.034	0.023
0.000	0.000	0.056	0.049	0.034
0.000	0.000	0.063	0.056	0.038
0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000



And for the pixel closest to the corner in the dark region would be similar to:

0.023	0.034	0.038	0.000	0.000
0.034	0.049	0.056	0.000	0.000
0.038	0.056	0.063	0.056	0.038
0.034	0.049	0.056	0.049	0.034
0.023	0.034	0.038	0.034	0.023



Analogously, on the edge the dominant part of the gaussian filter will impact on the light and on the dark region respectively.

Es.3

```
clc
close all
clear all

%a)
I = imread('input.jpg');
figure
imshow(I)

%b)
I_hsv=rgb2hsv(I);
I_h = I_hsv(:,:,1);
I_s = I_hsv(:,:,2);


%c)
h_t = 0.15;
h_margin = 0.04/2;
s_t = 0.5;
I_mask = I_h>(h_t-h_margin) & I_h<(h_t+h_margin) & I_s>s_t;

%d)
[r,c]=find(I_mask);
tl(1)=min(r);
tl(2)=min(c);
br(1)=max(r);
br(2)=max(c);

%e)
I_recipe = imread('recipe.jpg');

%f)
h = br(1)-tl(1)+1;
w = br(2)-tl(2)+1;
I_recipe = imresize(I_recipe,[h w]);

%g)
I_out = I;
I_out(tl(1):br(1),tl(2):br(2),:) = I_recipe;
figure
imshow(I_out)
```