Image processing for bioinformatics

Laboratory
Images, histograms and point operations

1 Description

This document presents examples of functions to perform simple point operations on images, implemented in Matlab.

In this task, the examples should be reproduced and the requested functions should be implemented.

2 Examples

2.1 Read and show images

Code	Image
| ```
1 % Read and show a RGB image
2 clc; clear; close all;
3 figure('Name','Show image','NumberTitle','off');
4 Img1 = imread('appleColor.jpg');
5 whos Img1
6 imshow(Img1)
``` <br><br> **Command window** <br><br> ``` Name    Size       Bytes   Class       Attributes
 Img1   375x500x3   562500 uint8 ``` | |

Table 1: Read and show a RGB image

Code	Image
| ```
1 % Read a RGB image, show a gryscale image
2 figure('Name','Show image','NumberTitle','off');
3 Img1 = imread('appleColor.jpg');
4 Img2 = rgb2gray(Img1); imshow(Img2); whos Img2
5 title(['imread − range of values: [', num2str(min(Img2(:))), ', ',
       num2str(max(Img2(:))), ']'])
6 Img3 = im2double(Img2(:,:,1)); imshow(Img3); whos Img3
7 title(['im2double − range of values [', num2str(min(Img3(:))), ', ',
       num2str(max(Img3(:))), ']'])
``` <br><br> **Command window** <br><br> ``` Name     Size           Bytes   Class     Attributes
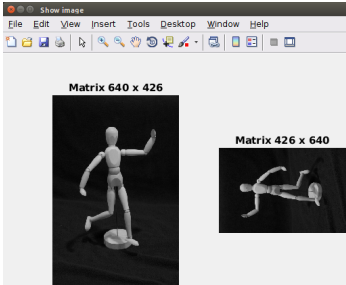 Img2   375x500   187500 uint8

 Name   Size   Bytes Class   Attributes
 Img3   375x500   1500000 double ``` | |

Table 2: Read a RGB image, show a gryscale image

Code	Image

```matlab
1  % Read and show a gryscale image
2  figure('Name','Show image','NumberTitle','off');
3  Img1 = imread('img02.png');
4  Img1 = Img1(:,:,1);
5  whos Img1
6  ['min=' num2str(min(Img1(:))) ', max=' num2str(max(Img1(:)))]
7
8  Img1 = double(Img1(:,:,1));
9  whos Img1
10 ['min=' num2str(min(Img1(:))) '; max=' num2str(max(Img1(:)))]
11 [m,n] = size(Img1);
12
13 subplot(1,2,1); imshow(Img1,[0,255]);
14 title(['Matrix ', num2str(m), ' x ', num2str(n)])
15 subplot(1,2,2); imshow(Img1',[0,255]);
16 title(['Matrix ', num2str(n), ' x ', num2str(m)])
```

Command window

```
Name       Size       Bytes    Class      Attributes
Img1     640x426     272640    uint8      'min = 1, max = 246'


Name       Size       Bytes    Class      Attributes
Img1     640x426    2181120    double     'min = 1; max = 246'
```
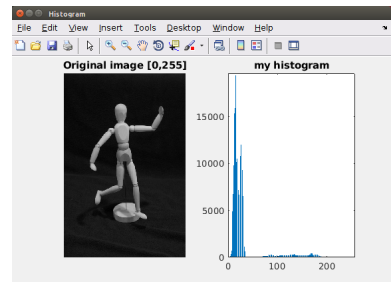

Table 3: Read and show a gryscale image

Code	Image

```matlab
1  % Histogram
2  figure('Name','Histogram','NumberTitle','off');
3  Img1 = imread('img02.png');
4  Img1 = (Img1(:,:,1));
5  [m,n] = size(Img1);
6  myHist = zeros(256,1);
7  for i = 1:m
8    for j = 1:n
9      myHist( Img1(i,j)+1 ) = myHist( Img1(i,j)+1 ) + 1;
10   end
11 end
12 subplot(1,2,1); imshow(Img1,[0,255]);
13 title('Original image [0,255]')
14 subplot(1,2,2); bar(myHist);
15 title('my histogram'); ylim([0 max(myHist)*1.01]);
```
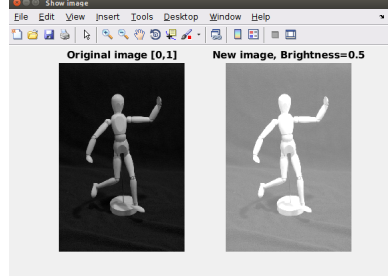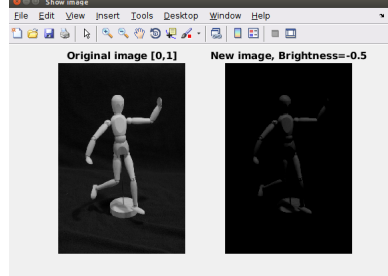

Table 4: Histogram

2.2 Point operations

Code	Image

```matlab
1  % Brightness, Brightness substraction *****************
2  clc; clear; close all;
3  br = 0.50;
4  figure('Name','Show image','NumberTitle','off');
5  Img1 = imread('img02.png');
6  Img1 = im2double(Img1(:,:,1));
7  [m,n] = size(Img1);
8  mat = zeros(m,n);
9  % mat = Img1+br;
10 for i = 1:m
11   for j = 1:n
12     mat(i,j) = Img1(i,j)+br;
13   end
14 end
15
16 subplot(1,2,1); imshow(Img1,[0,1]);
17 title('Original image [0,1]')
18 subplot(1,2,2); imshow(mat,[0,1]);
19 title(['New image, Brightness=',num2str(br)])
```


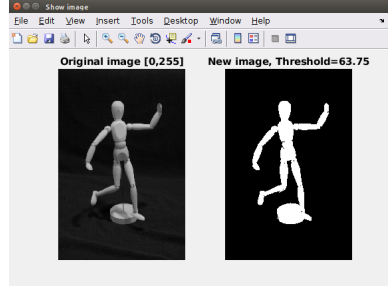
Table 5: Brightness and brightness substraction

Code	Image

```matlab
1  % Threshold **********************************************
2  th = 0.25*255;
3  figure('Name','Show image','NumberTitle','off');
4  Img1 = imread('img02.png');
5  Img1 = double(Img1(:,:,1));
6  [m,n] = size(Img1);
7  mat = zeros(m,n);
8  % mat = Img1 < th;
9  for i = 1:m
10   for j = 1:n
11     if Img1(i,j) < th
12       mat(i,j) = 0;
13     else
14       mat(i,j) = 255;
15     end
16   end
17 end
18 subplot(1,2,1); imshow(Img1,[0,255]); title('Original image [0,255]')
19 subplot(1,2,2); imshow(mat,[0,255]); title(['New image, Threshold=',num2str(th)])
```
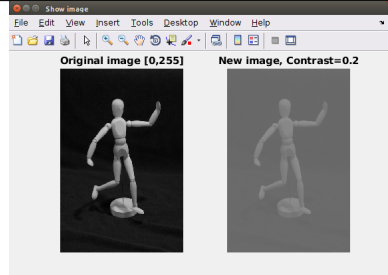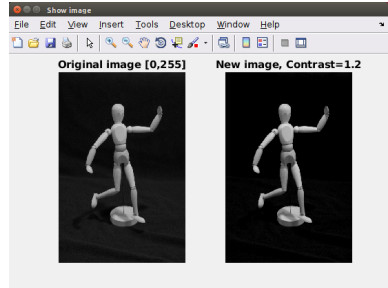

Table 6: Threshold

Code	Image

```matlab
1  % Contrast *******************************************
2  clc; clear; close all;
3  cr = .2;
4  figure('Name','Show image','NumberTitle','off');
5  Img1 = imread('img02.png');
6  Img1 = double(Img1(:,:,1));
7  [m,n] = size(Img1);
8  mat = zeros(m,n);
9      % mat = (Img1 − 0.5) * cr + 0.5;
10 for i = 1:m
11   for j = 1:n
12     mat(i,j) = (Img1(i,j) − 0.5*255) * cr + 0.5*255;
13   end
14 end
15
16 subplot(1,2,1); imshow(Img1,[0,255]); title('Original image [0,255]')
17 subplot(1,2,2); imshow(mat,[0,255]); title(['New image, Contrast=',
        num2str(cr)])
```
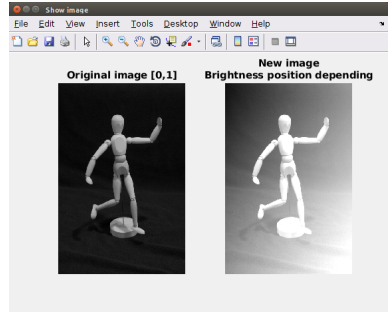
Table 7: Contrast

Code	Image

```matlab
1  % Brightness changes depending on the position *************
2  clc; clear; close all;
3  figure('Name','Show image','NumberTitle','off');
4  Img1 = imread('img02.png');
5  Img1 = im2double(Img1(:,:,1));
6  [m,n] = size(Img1);
7  mat = zeros(m,n);
8
9  for i = 1:m
10   for j = 1:n
11     mat(i,j) = Img1(i,j) + 0.5*i/m + 0.5*j/n;
12   end
13 end
14
15 subplot(1,2,1); imshow(Img1, [0,1]); title('Original image [0,1]')
16 subplot(1,2,2); imshow(mat, [0,1]); title({'New image', ['Brightness
        position depending']})
```

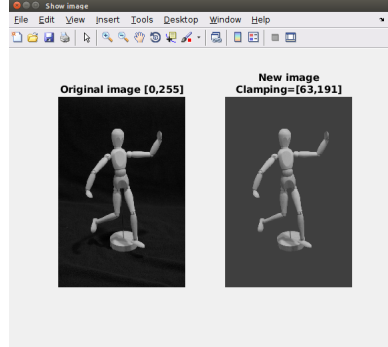Table 8: Brightness changes depending on the position

Code	Image
| ```matlab
% Clamping ****************
a = floor(0.25*255);
b = floor(0.75*255);
figure('Name','Show image','NumberTitle','off');
Img1 = imread('img02.png');
Img1 = double(Img1(:,:,1));
[m,n] = size(Img1);
mat = zeros(m,n);

for i = 1:m
  for j = 1:n
    if Img1(i,j) < a
      mat(i,j) = a;
    elseif b < Img1(i,j)
      mat(i,j) = b;
    else
      mat(i,j) = Img1(i,j);
    end
  end
end

subplot(1,2,1); imshow(Img1,[0,255]); title('Original image [0,255]')
subplot(1,2,2); imshow(mat,[0,255]);
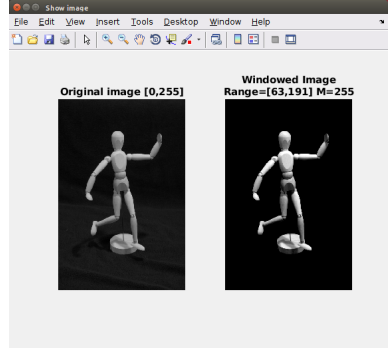title({'New image', ['Clamping=[',num2str(a),',',num2str(b),']']})
``` |  |

Table 9: Clamping

Code	Image
| ```matlab
% Intensity Windowing **************
a = floor(0.25*255);
b = floor(0.75*255);
M = 255;
figure('Name','Show image','NumberTitle','off');
Img1 = imread('img02.png');
Img1 = double(Img1(:,:,1));
[m,n] = size(Img1);
mat = zeros(m,n);

for i = 1:m
  for j = 1:n
    if Img1(i,j) < a
      mat(i,j) = 0;
    elseif b < Img1(i,j)
      mat(i,j) = M;
    else
      mat(i,j) = M * (Img1(i,j) - a) / (b - a);
    end
  end
end

subplot(1,2,1); imshow(Img1,[0,255]); title('Original image [0,255]')
subplot(1,2,2); imshow(mat,[0,255]); title({'Windowed Image',[ '
      Range=[',num2str(a),',',num2str(b),'] M=',num2str(M)]})
``` |  |

Table 10: Intensity Windowing

Code

```matlab
1  % Histogram equalization Matlab *********************************************
2  figure('Name','Show image','NumberTitle','off');
3  Img1 = imread('img02.png');
4  Img1 = (Img1(:,:,1));
5  [m,n] = size(Img1);
6
7  % Compute the histogram
8  [myHist,binLocations] = imhist(Img1);
9
10 % Normalize histogram
11 myHistNorm = myHist/(m*n);
12
13 % Cumulative histogram
14 myHistCum = cumsum(myHistNorm);
15
16 subplot(2,3,1); imshow(Img1,[0,255]); title('Original image')
17 subplot(2,3,2); bar(myHist); title('Histogram'); ylim([0 max(myHist)*1.2]);
18 subplot(2,3,3); plot(myHistCum); title('Cumulative histogram ');
19
20 Img3 = histeq(Img1); % Histogram equalization
21 % Compute the histogram
22 [counts,binLocations] = imhist(Img3);
23
24 subplot(2,3,4); imshow(Img3,[0,255]); title('Image with EH matlab')
25 subplot(2,3,5); bar(counts); title('EH matlab'); ylim([0 max(myHist)*1.2]);
26
27 % Normalize histogram
28 myHistNorm3 = counts/(m*n);
29
30 % Cumulative histogram
31 myHistCum3 = cumsum(myHistNorm3);
32
33 subplot(2,3,6); plot(myHistCum3); title('Cumulative EH matlab');
```

Image

Table 11: Histogram equalization

3 Assignment
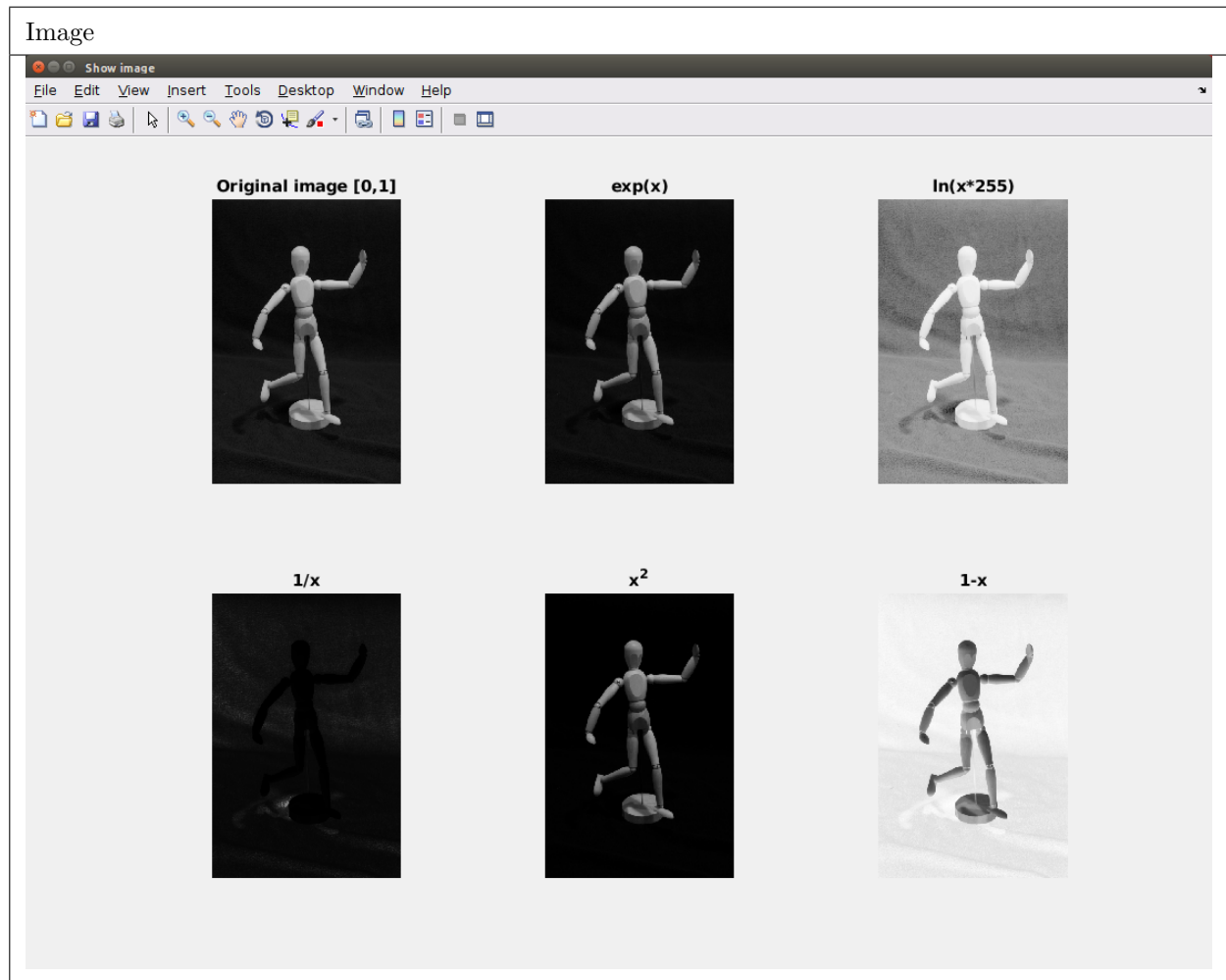
1. Implement two of the following point operations:

Table 12: Real-valued functions

2. Implement the histogram equalization (Table 11) without Matlab functions *imhist*, *cumsum* and *histeq*.

4 Solutions

1. Implement two of the following point operations:

> **Code - Real-valued functions**
>
> ```matlab
> %% Real−valued functions ********************************************
> clc; clear; %close all;
> figure('Name','Show image','NumberTitle','off');
> Img1 = imread('img02.png');
> Img1 = im2double(Img1(:,:,1));
> [m,n] = size(Img1);
>
> matExp = exp(Img1); % enhancing contrast of brighter regions
> matLog = log(Img1*255); % reducing contrast of brighter regions
> matInv = 1./(Img1);
> matPower2 = Img1.^2;
> matInverted = max(Img1(:)) − Img1;
>
> Img2 = mat2gray(matExp);
> Img3 = mat2gray(matLog);
> Img4 = mat2gray(matInv);
> Img5 = mat2gray(matPower2);
> Img6 = mat2gray(matInverted);
>
> subplot(2,3,1); imshow(Img1); title('Original image [0,1]')
> subplot(2,3,2); imshow(Img2); title('exp(x)')
> subplot(2,3,3); imshow(Img3); title('ln(x*255)')
> subplot(2,3,4); imshow(Img4); title('1/x')
> subplot(2,3,5); imshow(Img5); title('x^2')
> subplot(2,3,6); imshow(Img6); title('1−x')
> ```

2. Implement the histogram equalization (Table 11) without Matlab functions *imhist*, *cumsum* and *histeq*.

Code - My Histogram equalization

```
1  %% My Histogram equalization *********************************************
2  figure('Name','Show image','NumberTitle','off');
3  Img1 = imread('img02.png');
4  Img1 = (Img1(:,:,1));
5  [m,n] = size(Img1);
6  myHist = zeros(1,256);
7  myHistCum = zeros(1,256);
8  % Compute the histogram
9  for i = 1:m
10    for j = 1:n
11       myHist( Img1(i,j)+1 ) = myHist( Img1(i,j)+1 ) + 1;
12    end
13 end
14 % Normalize histogram
15 myHistNorm = myHist/(m*n);
16 % Cumulative histogram
17 tmp = 0;
18 for i = 1:256
19    tmp = tmp + myHistNorm(i);
20    myHistCum(i) = tmp;
21 end
22 % Compute image with histogram equalized
23 Img2 = zeros(m,n,'uint8');
24 for i = 1:m
25    for j = 1:n
26       Img2(i,j) = uint8(255*myHistCum( Img1(i,j)+1 ));
27    end
28 end
29 subplot(2,3,1); imshow(Img1,[0,255]); title('Original image')
30 subplot(2,3,2); bar(myHist); title('my histogram'); ylim([0 max(myHist)*1.2]);
31 subplot(2,3,3); plot(myHistCum); title('Cumulative histogram ');
32 myHist2 = zeros(1,256);
33 myHistCum2 = zeros(1,256);
34 % Compute the histogram
35 for i = 1:m
36    for j = 1:n
37       myHist2( Img2(i,j)+1 ) = myHist2( Img2(i,j)+1 ) + 1;
38    end
39 end
40 % Normalize histogram
41 myHistNorm2 = myHist2/(m*n);
42 % Cumulative histogram
43 tmp = 0;
44 for i = 1:256
45    tmp = tmp + myHistNorm2(i);
46    myHistCum2(i) = tmp;
47 end
48 subplot(2,3,4); imshow(Img2,[0,255]); title('Image with EH')
49 subplot(2,3,5); bar(myHist2); title('my EH'); ylim([0 max(myHist2)*1.2]);
50 subplot(2,3,6); plot(myHistCum2); title('My Cumulative EH ');
```