
2D Image denoising using undecimated wavelet transform

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Initializations

```
clear; clc; close all
rmse = @(y,x) sqrt( sum( (y(:)-x(:)).^2) / numel(y) );
psnr = @(x,y) 10*log10 ( 1 / rmse(im2double(x),im2double(y))^2);
addpath Functions
addpath Functions/WaveletFunctions
```

Load Image and generate Noisy version of the image

```
S = rgb2gray(imread('peppers.png'));
S = double(S);

rng('default')
sigma = 50;
Y = S + sigma*randn(size(S));
J = 5;
[AH, A, normA] = MakeTransforms('2D-CDWT',size(Y),J);

figure(1), clf
subplot(1,2,1)
imshow(uint8(S));
title('Original Image')

subplot(1,2,2)
imshow(uint8(Y));
title(sprintf('Noisy Image, PSNR = %2.2f dB',psnr(uint8(S),uint8(Y))))
```

Original Image



Noisy Image, PSNR = 14.70 dB



Denoise the image

```
Lam_l1 = 0.45*sigma;  
Lam_ncvx = 0.65*sigma;  
a = 1/(Lam_ncvx);  
mu = 2;  
Nit = 15;  
nit = 1:Nit;  
  
x = bp_ncvx2DCWT(Y,A,AH,J,Lam_ncvx,a,mu,Nit,'atan');  
xL1 = bp_ncvx2DCWT(Y,A,AH,J,Lam_l1,1,mu,Nit,'l1');
```

Plot the denoised images

```
figure(2), clf  
subplot(1,3,1)  
imshow(uint8(Y))  
title(sprintf('Noisy Image \nPSNR = %2.1f dB',psnr(uint8(S),uint8(Y))))  
box off  
  
subplot(1,3,2)  
imshow(uint8(xL1))  
title(sprintf('L1 \nPSNR = %2.1f dB',psnr(uint8(S),uint8(xL1))))  
box off
```

```
subplot(1,3,3)
imshow(uint8(x))
title(sprintf('Non-convex \nPSNR = %2.1f dB',psnr(uint8(S),uint8(x))),...
        'horizontalAlignment','center')
box off
```

Noisy Image
PSNR = 14.7 dB



L1
PSNR = 26.4 dB



Non-convex
PSNR = 27.9 dB

