CSE377 Spring 2023 Homework 5 – Spatial Filtering (12 pts)

Due March 31 2023 11:59PM via Brightspace.

1. (1pt) Load the input X-ray image 'WholeBoneScan.png' as $f(x,y)$. Show the input image;

2. (3pt) Unsharp masking and highboost filtering.
   Blur the image by a 5-by-5 box filter $h(x,y)$: $\overline{f(x,y)} = f(x,y) \otimes h(x,y)$, where $\otimes$ denotes convolution;
   Subtract the blurred image from the original, defined it as the mask: $g_{mask} = f(x,y) - \overline{f(x,y)}$;
   Add the mask to the original: $g(x,y) = f(x,y) + k g_{mask}(x,y)$.
   Choose k =1, show the unsharp masking result $g(x,y)$;
   Choose $k > 1$, show the highboost filtering result $g(x,y)$. You can check the effect of different k values.

3. (2pt) Sharpening by Laplacian filtering.
   Define a Laplacian kernel $h(x,y) = [-1,-1,-1;\ -1,8,-1;\ -1,-1,-1]$;
   Filter the original image by this Laplacian kernel: $\nabla^2 f(x,y) = f(x,y) \otimes h(x,y)$;
   Add the second-order derivative to the original image: $\mathrm{g(x,y)} = \mathrm{f(x,y)} + \mathrm{c}\nabla^2 f(x,y)$. Show $g(x,y)$. You can check the effect of different c values.

4. (3pt) Calculating the gradient.
   Define the sober filters: $h_x(x,y) = [-1,-2,-1;\ 0,0,0;\ 1,2,1]$; and $h_y(x,y) = [-1,0,1;\ -2,0,2;\ -1,0,1]$;
   Calculate the first-order derivatives: $\nabla_x f(x,y) = g_x = f(x,y) \otimes h_x(x,y)$ and $\nabla_y f(x,y) = g_y = f(x,y) \otimes h_y(x,y)$. Show g_x and g_y.
   Calculate the gradient magnitude: $\|\nabla f(x,y)\|_2 = \sqrt{g_x^2 + g_y^2}$. Show the magnitude.
   Blur the gradient magnitude image by a 5-by-5 box filter $h(x,y)$: $\overline{\|\nabla f(x,y)\|_2} = \|\nabla f(x,y)\|_2 \otimes h(x,y)$. Show $\overline{\|\nabla f(x,y)\|_2}$. Normalize this blurred magnitude image with the values in [0,1] for the next step.

5. (1pt) Multiple the Laplacian filtered image $\nabla^2 f(x,y)$ from step 2 with the gradient mask image (blurred magnitude image from step 4):
   $$\nabla^2 \widetilde{f(x,y)} = \nabla^2 f(x,y) .* \overline{\|\nabla f(x,y)\|_2}$$, where .* stands for elementwise multiplication.
   Show $\nabla^2 \widetilde{f(x,y)}$.

6. (1pt) Add the weighted second-order derivative to the original image: $\mathrm{g}\widetilde{\mathrm{(x,y)}} = \mathrm{f(x,y)} + \mathrm{c}\nabla^2 \widetilde{f(x,y)}$. Show $\mathrm{g}\widetilde{\mathrm{(x,y)}}$.

7. (1 pt) Apply the power-law intensity transform $s = r^{0.5}$ onto $\mathrm{g}\widetilde{\mathrm{(x,y)}}$. Show the output image after the intensity transformation.

   Note, the math notations are consistent with the lecture slides.