CSE585/EE555: Digital Image Processing II
Spring 2023
Project #4 — Texture Segmentation

assigned:	Thursday, 30 March 2023
due:	Sunday 16 April 2023
reading assignment:	Bovik paper and browse L18-supplement

Per the discussion of L17-L18, you are to implement the Gabor filter:

$$m(x,y) \;=\; |I(x,y) \;*\; h(x,y)|$$

where I denotes the input image, h is a GEF, and g is a circularly-symmetric Gaussian ($\sigma_x = \sigma_y = \sigma$):

$$h(x,y) \;= g(x,y) \cdot \exp\left[j2\pi F(x\text{cos}\theta \;+\; y\text{sin}\theta)\right] = \; g(x,y) \cdot \exp\left[j2\pi(Ux + Vy)\right]$$

$$g(x,y) = \frac{1}{2\pi\sigma^2}\exp\left\{\frac{-(x^2+y^2)}{2\sigma^2}\right\}$$

As we know, parameters (F, θ, σ) specify the GEF. You are to also implement the smoothing filter:

$$m'(x,y) \;=\; m(x,y) \;*\; g'(x,y)$$

where g' is another circular-symmetric Gaussian using a different σ. To apply the Gabor filter, precompute the GEF, so it has width $4\sigma + 1$ pixels. To apply the smoothing filter, precompute the Gaussian, so it has width $4\sigma + 1$ pixels. All filtering can be done using straightforward spatial convolution, as discussed in class. Perform the processing for as many image points as possible— remember that values near the outer perimeter of the image cannot be completely processed. When displaying results, zero out unprocessed perimeter areas. Also, as a special caution, you will need to scale some of the results such as $m(x,y)$ and $m'(x,y)$ to display them meaningfully.

Perform the following tests:

1. Apply the Gabor filter with $F = 0.059$ cycles/pixel, $\theta = 135^o$, and $\sigma = 8$ to the image "texture2." This image contains "-" and "/" textures, both strongly ordered per Rao's texture taxonomy (see L17). Next, apply the smoothing filter to $m(x,y)$ with $\sigma = 24$. **Note: images "texture1" and "texture2" are binary-valued images — they are NOT empty black images!**
2. Apply the Gabor filter with $F = 0.042$ cycles/pixel, $\theta = 0^o$, and $\sigma = 24$ to the image "texture1." This image contains disordered textures consisting of "+" and "L" texels. Next, apply the smoothing filter to $m(x,y)$ with $\sigma = 24$.
3. Apply an appropriate Gabor filter to the image "d9d77." This image contains disordered Brodatz textures: "d9" is grass lawn and "d77" is cotton canvas. No smoothing filter is needed in this case. (See L18 for appropriate parameters for "d9d77" and "d4d29".)
4. Apply an appropriate Gabor filter and follow-up smoothing filter to the image "d4d29," where "d4" is pressed cork, while "d29" is beach sand (both disordered textures).

For each test above:

1. Give $I(x,y)$, $m(x,y)$, and, if computed, $m'(x,y)$. Display $m(x,y)$ and $m'(x,y)$ as gray-scale images <u>and</u> 3D plots.
2. Threshold the final filtered output (either $m(x,y)$ or $m'(x,y)$) to give a segmented image, where the goal is to discriminate one texture from another. You can pick thresholds manually—be sure to give your thresholds. To display the segmented result, superimpose the segmented result onto the original image.

Fully discuss your implementation and results. How good are the segmentations?

What portion of each image could actually segmented; i.e., give the x and y limits delineating the portion of an image you could segment.