Indian Institute of Technology Jodhpur
CSL7360: Computer Vision
Practice Questions Set 1

1. Compare the time complexity of convolution with a nn filter when using
   (a) direct convolution with the 2-D mask
   (b) a separable kernel

2. Prove that convolving a 1-D signal twice with a Gaussian kernel of standard deviation σ is equivalent to convolving the signal with a Gaussian kernel of $\sigma_c = \sqrt{2}\sigma$, scaled by the area of the Gaussian filter.

3. Explain why the (ρ, θ) parametrization for lines leads to a better discretization of the Hough parameter space than (m, c) in $y = mx + c$. Compare the accuracies of the parameter estimates you can hope to achieve in both cases, given the search for the maxima must take place in a reasonable time

4. Consider the following 1D filter $g = \frac{1}{4}\begin{bmatrix}1 & 2 & 1\end{bmatrix}$, which also serves as a very rough size-3 approximation of a 1D Gaussian filter. We can transpose the filter to create an equivalent 1D filter $g^\top = \frac{1}{4}\begin{bmatrix}1\\2\\1\end{bmatrix}$ that applies a blur in the vertical direction. Using zero-padding and full output size, compute $H = g * g^\top$. The filter H is an instance of a special kind of filter called a separable filter, which has the property that the result of the 2D filtering operation can be computed by doing two 1D filtering operations in series. Prove that convolving an image F with H gives the same result as convolving it with g, then convolving the result with $g^\top$. Does the above proof hold true for this particular filter if you use cross-correlation instead of convolution?

5. Extraction of visual features from images often involves convolution with filters that are themselves constructed from combinations of differential operators. One example is the Laplacian $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ of a Gaussian $n(x, y, \sigma)$ having scale parameter σ, generating the filter $\nabla^2 n(x, y, \sigma)$ for convolution with the image $I(x, y)$. Explain in detail each of the following three operator sequences, where $*$ signifies two-dimensional convolution.
   (a) $\nabla^2[n(x, y, \sigma) * I(x, y)]$
   (b) $n(x, y, \sigma) * \nabla^2 I(x, y)$
   (c) $[\nabla^2 n(x, y, \sigma)] * I(x, y)$

   What are the differences amongst them in their effects on the image?

6. At a pixel in an image, the covariance matrix is given as $\begin{bmatrix}6 & 0\\0 & 5\end{bmatrix}$. Is it a corner pixel?