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## **Selected Problems**

Problem: Demonstrate that the 2D Gaussian function

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

is a separable function.

Problem: Given a 1D Gaussian function

$$f(x) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left(\frac{-x^2}{2\sigma^2}\right)$$

compute a Gaussian kernel of size 5 for 1D convolution with  $\,\sigma^2{=}1\,$  .

**Problem:** Create a 2D Gaussian convolution kernel using the 1D kernel from the previous problem.

**Problem:** Convolve a normalized 1D Gaussian kernel of size 5 with  $\sigma^2=1$  with the following row of pixels:

0	0	0	0	0	10	20	30	40	50
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and put the result in this table:

NULL NULL		NULL	NULL
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**Problem:** Let's say we have 1000 image points that we think fit a 2D line in the resolution of a given problem. Also suppose we know about 30 percent of that data is corrupt. No matter what, we decide we are going to use RanSaC and iterate ten times, no more. Hence, ten times we are going to select 2 image points and fit a line, and evaluate how good that fit is with the rest of the points. What is the probability that one of these ten random choices of two points yields the right solution (i.e. the two chosen points are inliers)?

**Problem:** How many iterations would be needed to be sure at 90% that the best solution is correct?

**Problem:** Given a 5-point central difference formula:

$$f'(x) = \frac{-f(x+2h) + 8f(x+h) - 8f(x-h) + f(x-2h)}{12h}$$

Find the corresponding derivative kernel.

**Problem:** Derive the following signal at i=6 using the kernel obtained in the previous question:

1	2	3	4	5	6	7	8	9	10	11	12	13
												1

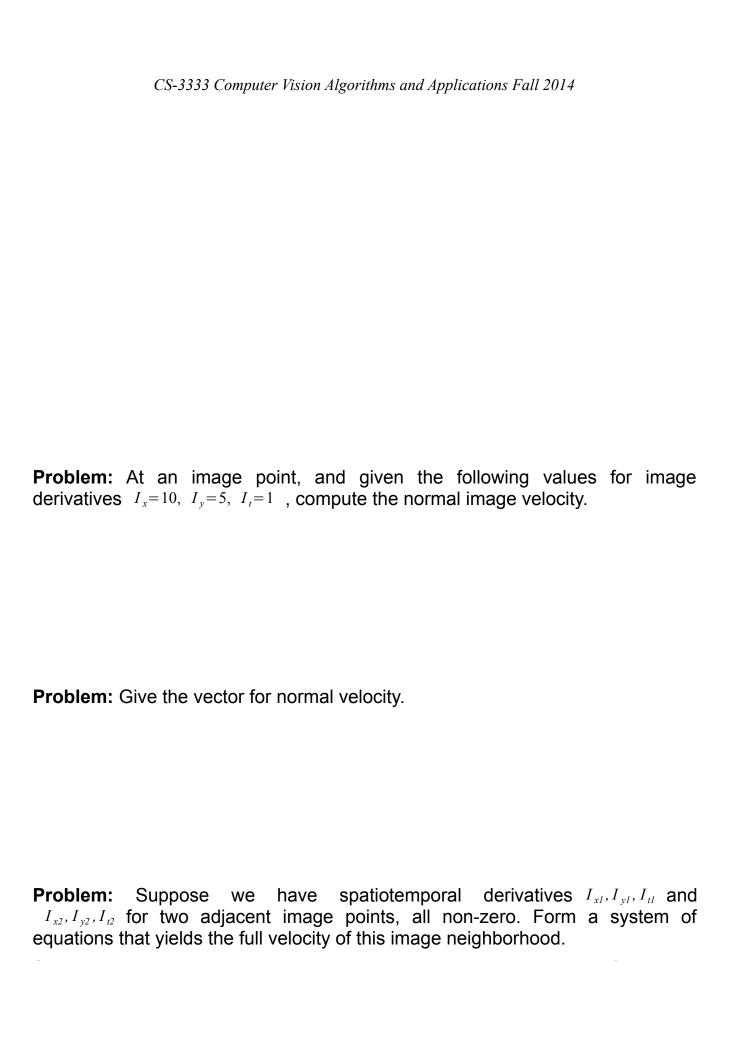
**Problem:** Suppose we have these two 3D points  $P_1 = (X_1, Y_1, Z_1) = (0,0,50)$  and  $P_2 = (X_2, Y_2, Z_2) = (1,1,50)$  in a camera coordinate system with focal length f = 10. What is the perspective projection of these two points onto the imaging plane of the camera?

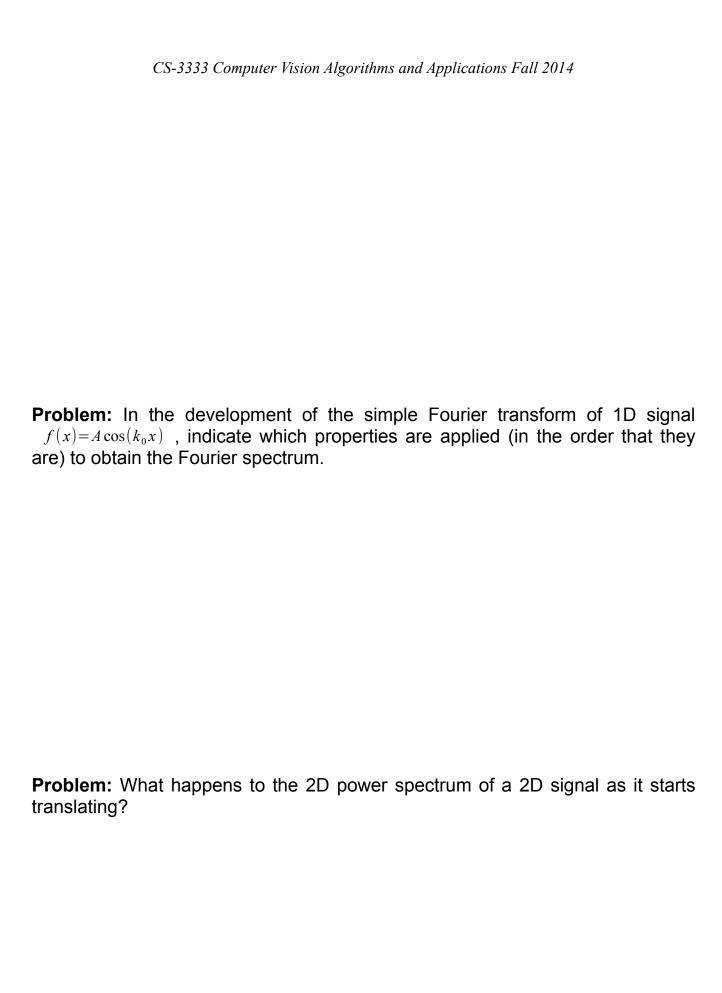
**Problem:** What is the image disparity between these two points?

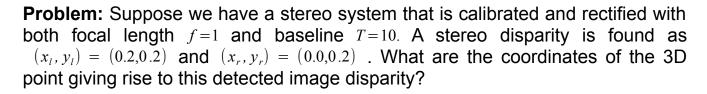
**Problem:** Suppose a 3D point  $P_1 = (10,10,100)$  in camera coordinates with f = 10 as before. Let this point translate by  $\vec{T} = (1.0,0.0,0.0)^T$  and rotate by  $\vec{\omega} = (0.0,0.0,0.0)^T$ . Compute the 3D velocity of this point.

**Problem:** Prove that:

$$f\frac{P}{Z}\frac{d}{dt} = \begin{bmatrix} \frac{T_z x - f T_x}{Z} - f \omega_y + \omega_z y + \frac{\omega_x x y}{f} - \frac{\omega_y x^2}{f} \\ \frac{T_z y - f T_y}{Z} + f \omega_x - \omega_z x - \frac{\omega_y x y}{f} + \frac{\omega_x y^2}{f} \end{bmatrix} = \begin{bmatrix} v_x \\ v_y \end{bmatrix}$$







**Problem:** Given two points  $p_1 = (x_1, y_1) = (1,3)$  and  $p_2 = (x_2, y_2) = (3,5)$  that are on a 2D line, use the Hough transform to obtain the equation of this line.