

Robotics (CPS 1/296) : Homework 1

Due February 8, 2007

1 Statistics Warm Up

In class, we gave an expression for the variance of the sum of two random variables. Show how this formula simplifies when the two variables are independent. Note: I don't want a trivial answer noting that the correlation is 0; I want you to do the algebra and show how independence algebraically causes some terms to go to 0.

2 Continuous Distributions

Determine the mean of the exponential distribution (shown in class) by writing out and solving the integral.

3 The Normal Distribution

Show that the sum of two independent, mean 0, variance 1 Gaussian variables also has a Gaussian distribution. You will need to solve an integral to do this. Hint: If you get stuck, try a change of variables.

4 Coding warmup

Write some code to read a file from ".pgm" format into an array and some code to write your array back out again in the same format. This is the simplest to use image format, the details of which can be found by doing a "man pgm" on any unix machine. You should also use the opportunity to familiarize yourself with the unix "convert" utility, which converts between nearly all image formats. Try a "man convert". The convert utility is part of the open source imagemagick suite (www.imagemagick.org), which can be installed on most machines.

For this problem, you should turn in your code, and an example of how it works. A good way to do this would be to start with an image you like, say "foo.jpg". Do a "convert foo.jpg foo.pgm" to create a pgm. Read in the file to memory using your program, then write it out again to, for example, "bar.pgm". If you don't have a program that can read pgm files, you can do a "convert bar.pgm bar.jpg". The only difference between "foo.jpg" and "bar.jpg" should be that the latter will be grayscale.

5 Discarding Hot Pixels

Write some code that searches an image and notes any "hot" pixels. A hot pixel is a saturated (intensity 255) pixel surrounded by unsaturated pixels. This could happen for a valid reason, but it typically happens from sensor defects or severe dark current non-uniformity. This is necessary because we will want to exclude hot pixels for the next questions. Test your code by adding a hot pixel to an image, using your answer to the previous question, then verifying that your code can find it. Turn in your code and an example of how it works.

6 Dark Current

Write some code that ignores hot pixels and computes the mean luminance level in an image. Using the images I have provided, determine how dark current changes with exposure time and with temperature. Comment on how this matches Kodak's sensor noise model. Turn in your code, along with your output on the sample images and your comments on the results.

7 Photon Shot Noise

Use your code to estimate how photon shot noise is changing with luminance. Hows does this match theory? Turn in your code, sample output, and comments.