Astro 503 Final Problems

Due Tuesday, May 2

1. **MCMC:** Use the Metropolis algorithm to generate a point set that samples the posterior distribution $P(\bar{x}_1, \bar{x}_2, C_{11}, C_{22}, C_{12}|D)$ of the parameters of a two-dimensional Gaussian distribution

$$P(x_1, y_1|\bar{x}_1, \bar{x}_2, C_x) = |2\pi C|^{-1/2} \exp\{-(x-\bar{x})^T C^{-1}(x-\bar{x})/2\}. \quad (1)$$

   I will supply a sequence of data pairs $\{x_1, x_2\}$ that comprise the data D, and you can assume a uniform prior in all the model parameters. Once you have a chain that looks burned in and has a few thousand points in it, report:

   (a) The maximum-likelihood parameter set.

   (b) The mean parameter set.

   (c) The variance of each parameter when marginalized over the other 4.

2. **Dark Energy III:** Repeat the fit of the flat, constant-w cosmology to the joint SN-gold sample and the WMAP constraints as summarized in the last homework, this time using the Markov-Chain Monte Carlo method. Then plot the marginalized distribution for w.

3. **Convolution:** The data file supplied contains the values of the pixels in a 1024×1024 image. Read this image into an array structure, then convolve the image with a Gaussian kernel $K(x, y)$ that is 64×64 pixels and $\sigma = 8$ pixels, $K(x, y) = \exp(-r^2/2\sigma^2)/2\pi\sigma^2$. Try the convolution three ways and report the execution time for each:

   (a) The "dumb" way with direct convolution.

   (b) By successive 1d direct convolutions using the fact that the kernel is seperable.

   (c) By running a 2d FFT algorithm.

   Be sure that your timings do not include the time spent reading the image in from the file, since the character-based I/O will be slow. Take a look at the input and output images.

If you need assistance with plotting the data or looking at images, see me for some software to use.