Computational Physics
Homework 3

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Problem 7.2 (a) Below I have plotted the data of sunspots over time. From looking at this data we can predict a periodic cycle of roughly 150 months.

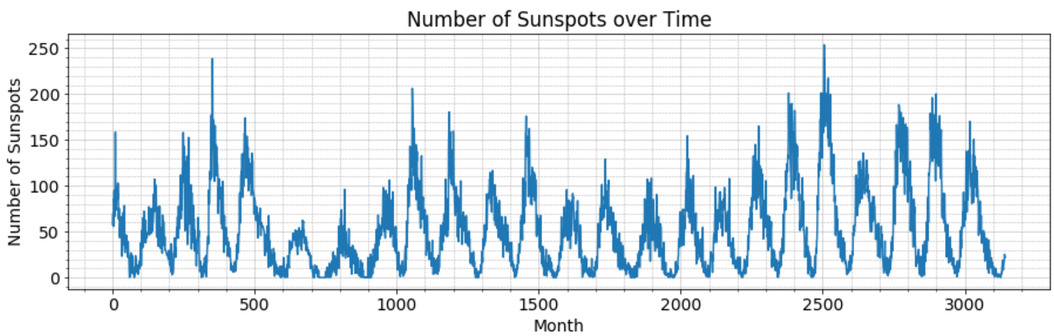

Figure 1: Number of sunspots over time.

(b) I have reproduced this plot of the power spectrum below and the code is accessible in the Jupyter notebook.

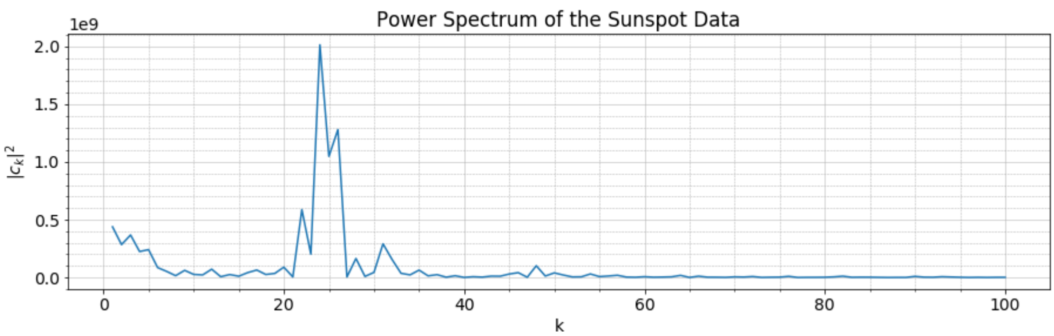

Figure 2: Power spectrum (or Fourier coefficients) of the sunspots data.

(c) We can identify this k_{max} using $k_{max} = \arg\max_k |c_k|^2 = 24$, so the peak in this plot corresponds to $k = 24$. This corresponds to a sine wave of $\sin\left(\frac{2\pi kt}{N}\right)$ which has period $T = 2\pi\frac{N}{2\pi k} = \frac{N}{k} \approx 131$ months. This is roughly our initial guess.

Problem 7.9 (a) This code is visible in the Jupyter notebook and I produced the photo in grayscale below.

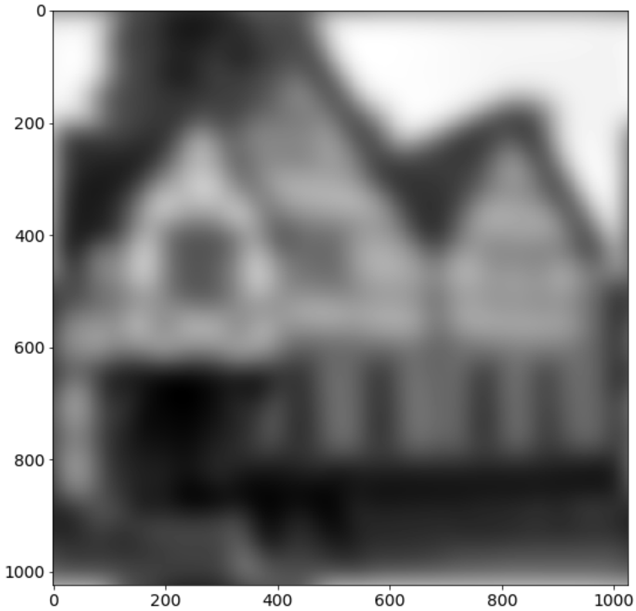

Figure 3: Blurry photo.

(b) I have reproduced this plot below. The spread on the Gaussian is not as visible as in Newman's, but that is probably just do to the brightness of his plot.

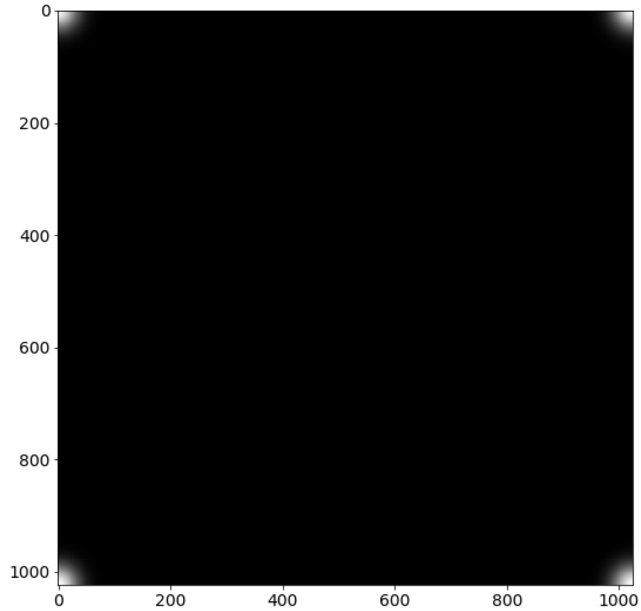

Figure 4: Gaussian point spread function with $\sigma = 25$.

(c) The result of the deconvolution can be seen in the figure below.

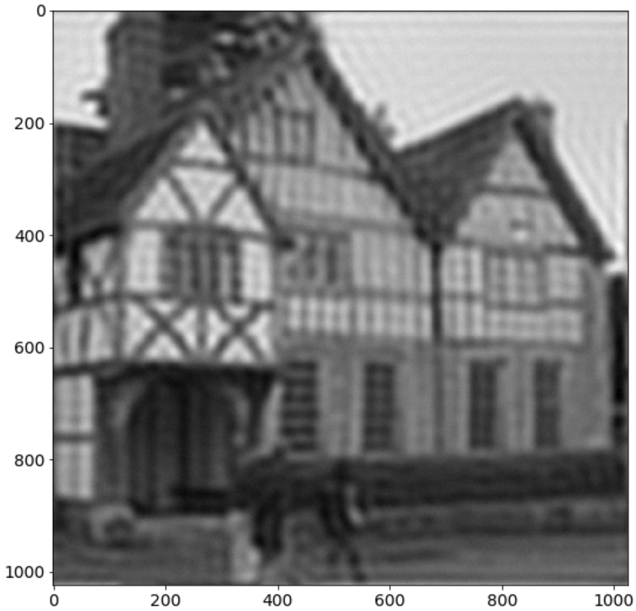

Figure 5: The sharpened image from deconvolution.

(d) There are two major problems with this approach to sharpening images. The biggest problem is choosing your smoothing function, which requires prior knowledge of the faulty process that blurred the image. The second problem is numerical, because if the Fourier transform of the smoothing function has really small values then when you divide by these numbers you can get roundoff error which may approximate these values as zeros and lead to errors. Even if you ignore these coefficients then you are still throwing away information, making the deconvolution imperfect.