PHYS 410/510 Fall 2024 Homework 7
Bret Brouse Jr. (11/14) (Late submission)

I fought a lot with Julia (many hours) and finally gave up and decided to start from scratch with Python (especially once I reached problem 2 and the radial center function).

Problem 1 (Gaussian MLE and number of photons).

Solution.

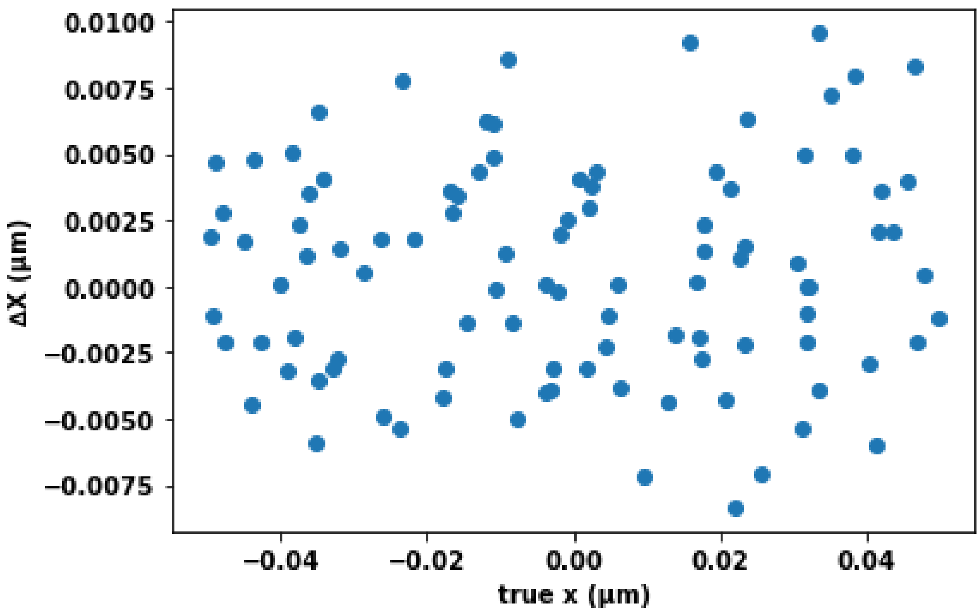
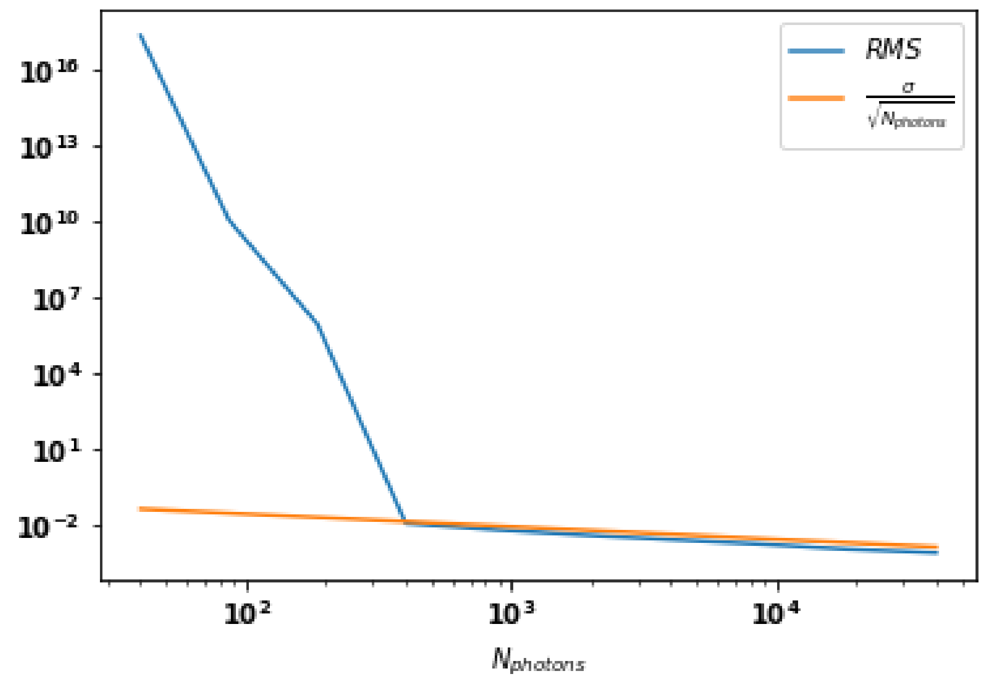


Figure 1: Sure looks unbiased to me!



(c) It makes sense to compare the RMS error to $\sigma/\sqrt{N_{photon}}$ since we see as we increase N_{photon}, the RMS error declines close tot he theoretical limit. I'd like to do this again with many more to see if I can 'smooth' out that RMSE curve.

Problem 2 (Radial-symmetry-based particle localization).

Solution. (a) The radial center calculations took roughly 0.075 seconds where as for the previous homework, centroids took 12ms. For MLE on the last homework, it took about 1.8 seconds. Therefore, this is faster than the MLE calculations but slower than the centroids.

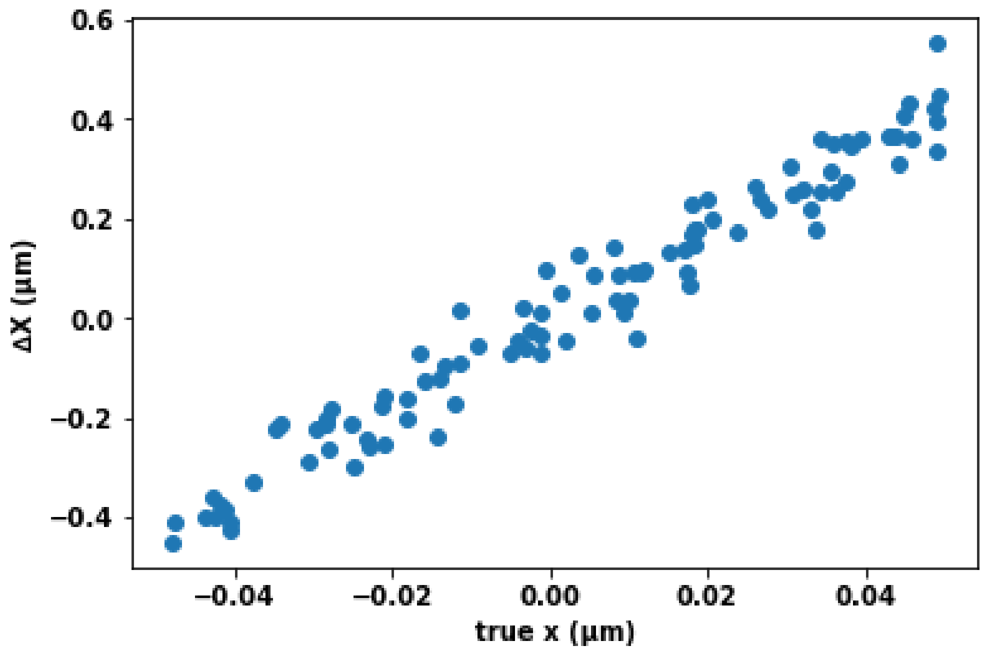


Figure 2: (b) This looks biased since there's a clear linear relationship between the position and the error.

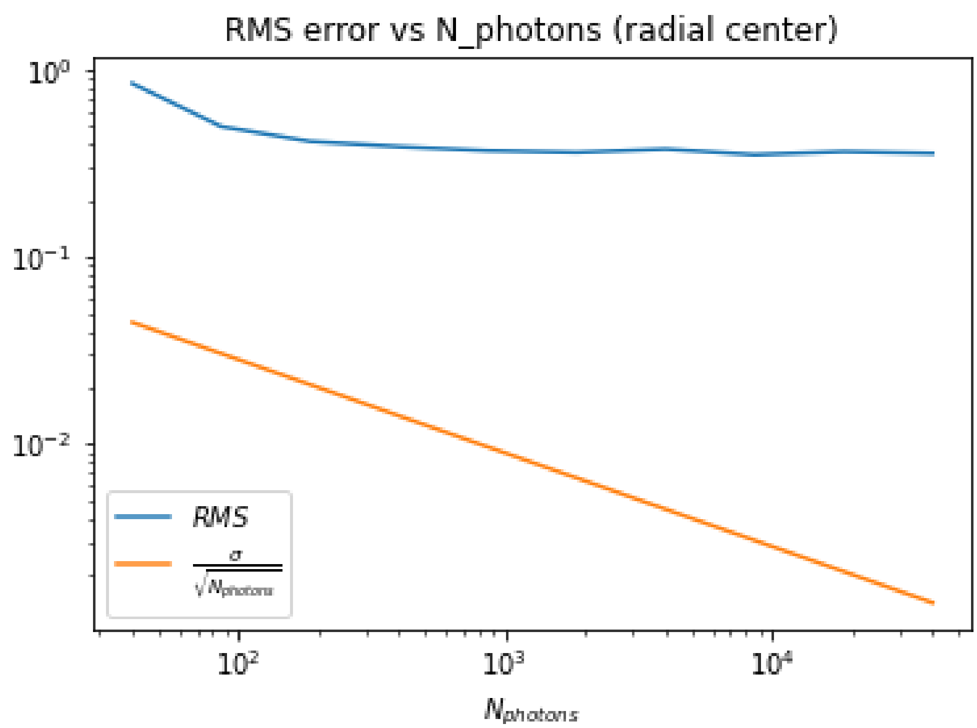


Figure 3: (c) This time, we don't see the RMS error tend to the theoretical limit but to some value where it levels out. I'm curious what the limit of this would be theoretically.

Problem 3 (Assessing deconvolution).

Solution.

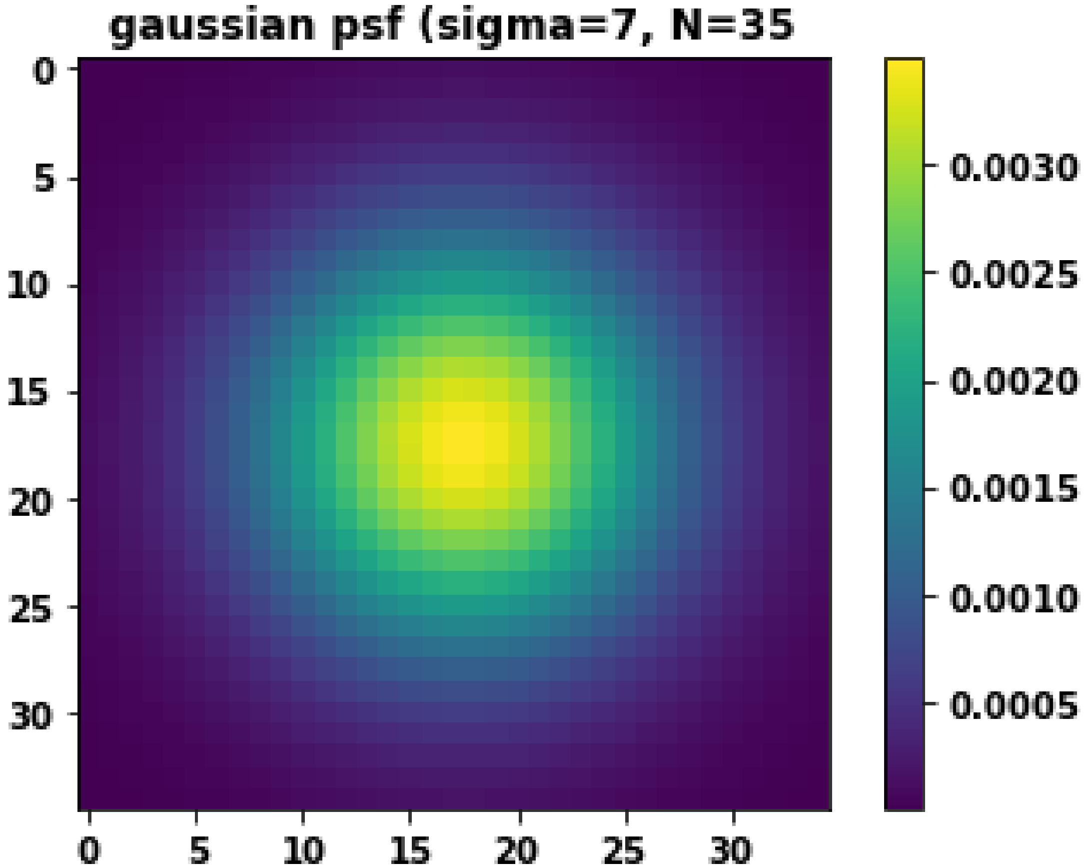


Figure 4: (a) This probably could have just been copied over from the previous homework!

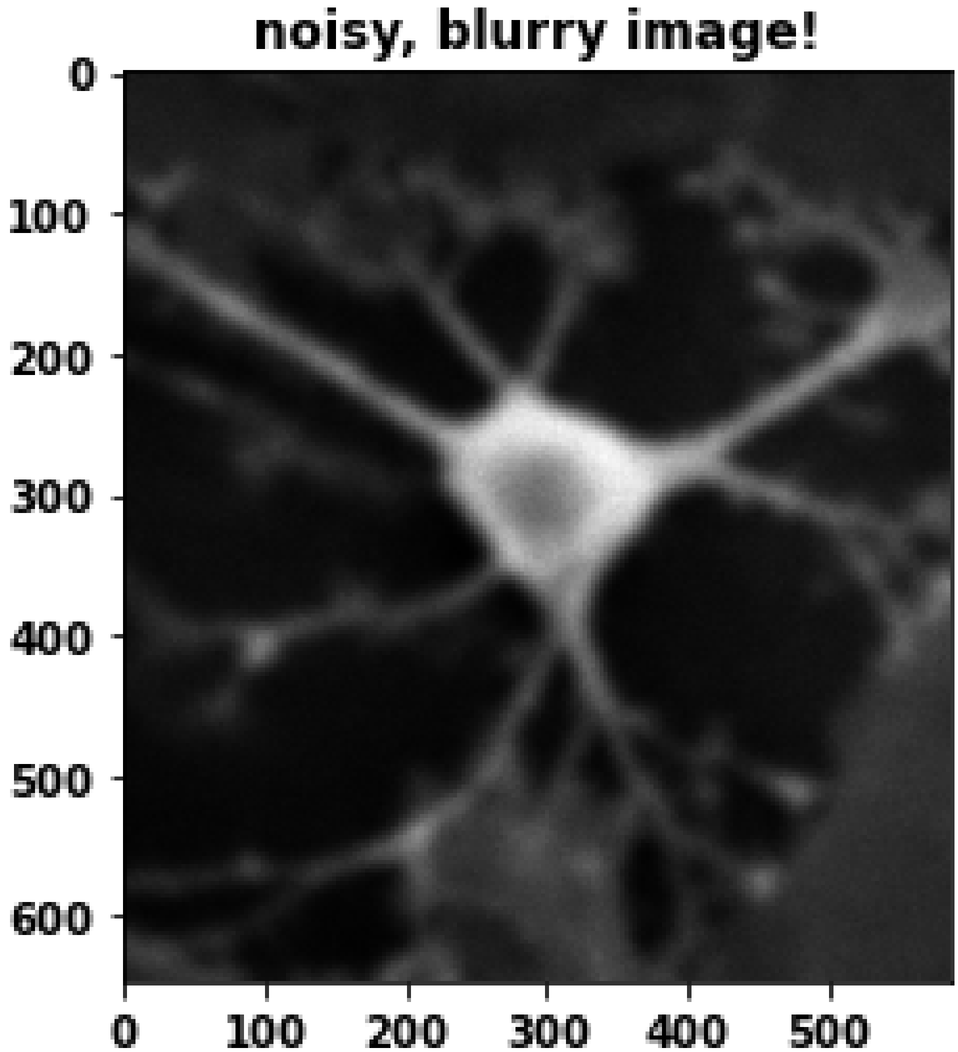


Figure 5: (b) The image after we convolve it with the gaussian psf above and adding some noise.

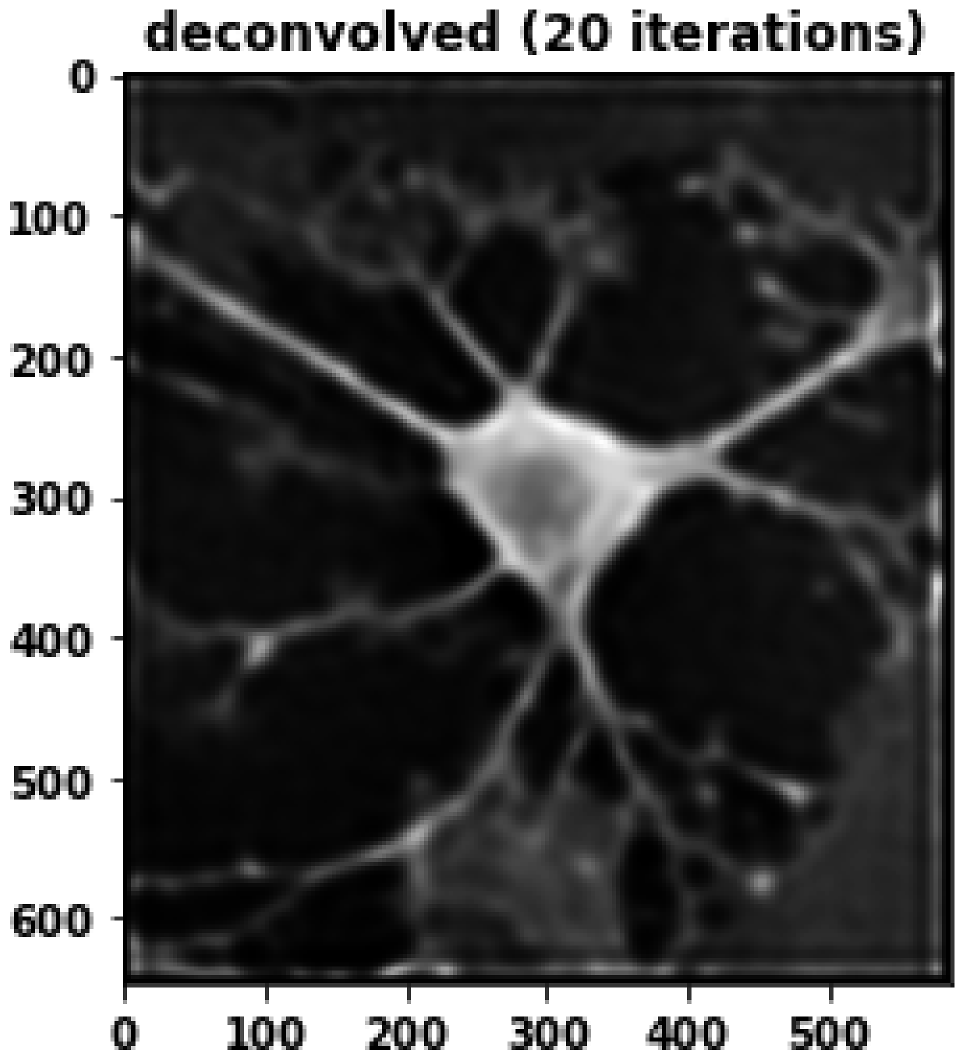


Figure 6: (c.1) After deconvolving the image directly (20 iterations) we can see the ‘ringing’ mentioned in the question at the edges.

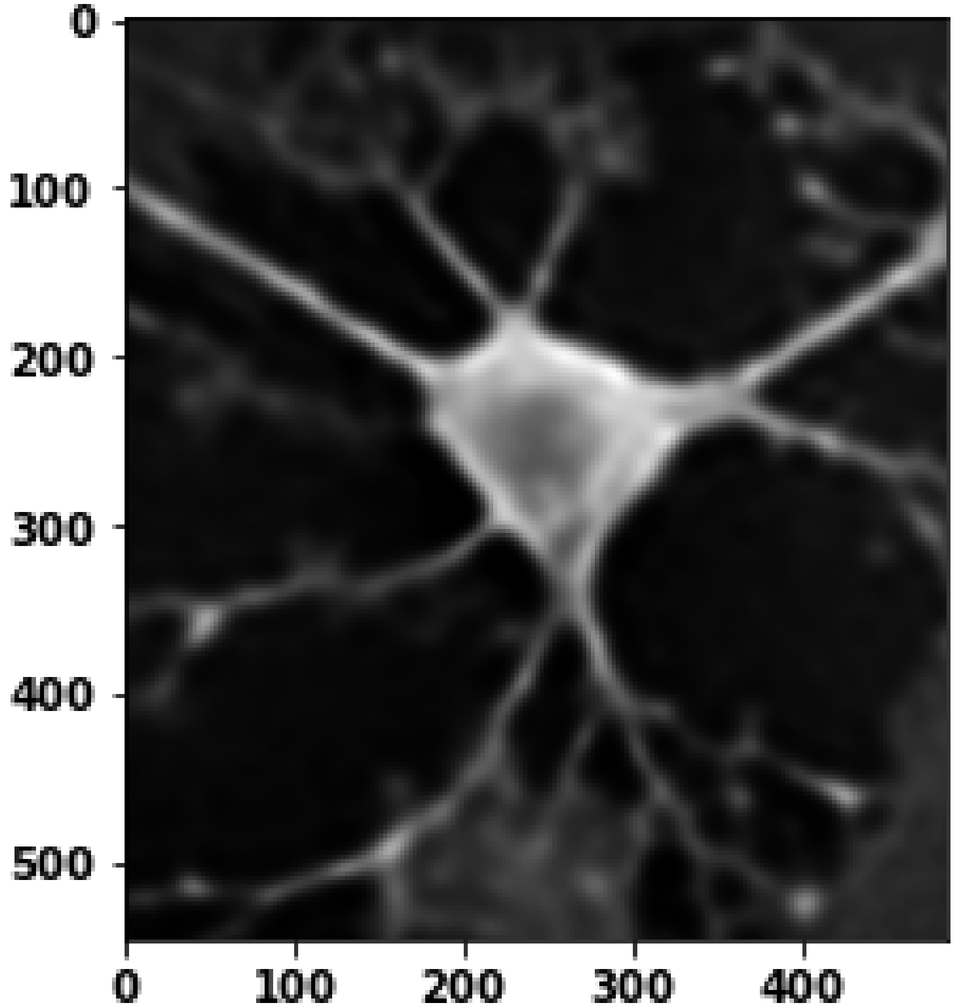


Figure 7: (c.2) I chose a nice flat number 50 to clip the edges of the image and get rid of the rings. The result is that we lose some of the image but we still have the central subject in sight. The RMSE prior to clipping was 30.28 whereas after clipping it was 7.85.

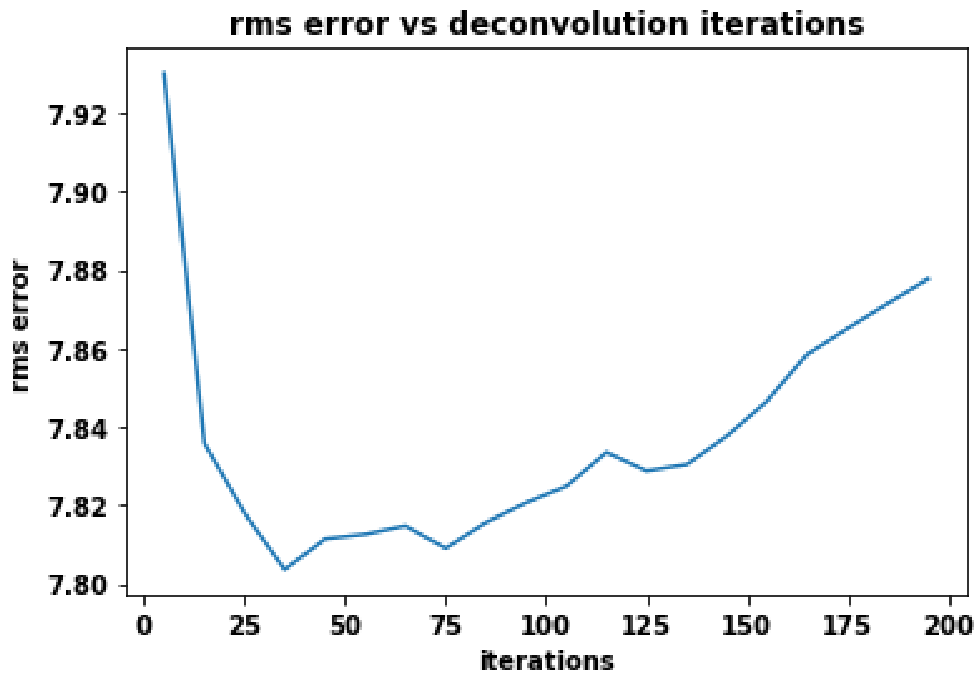


Figure 8: (d) The RMSE as we increase deconvolution iterations. It starts high as expected but has a clear minimum at roughly 30.

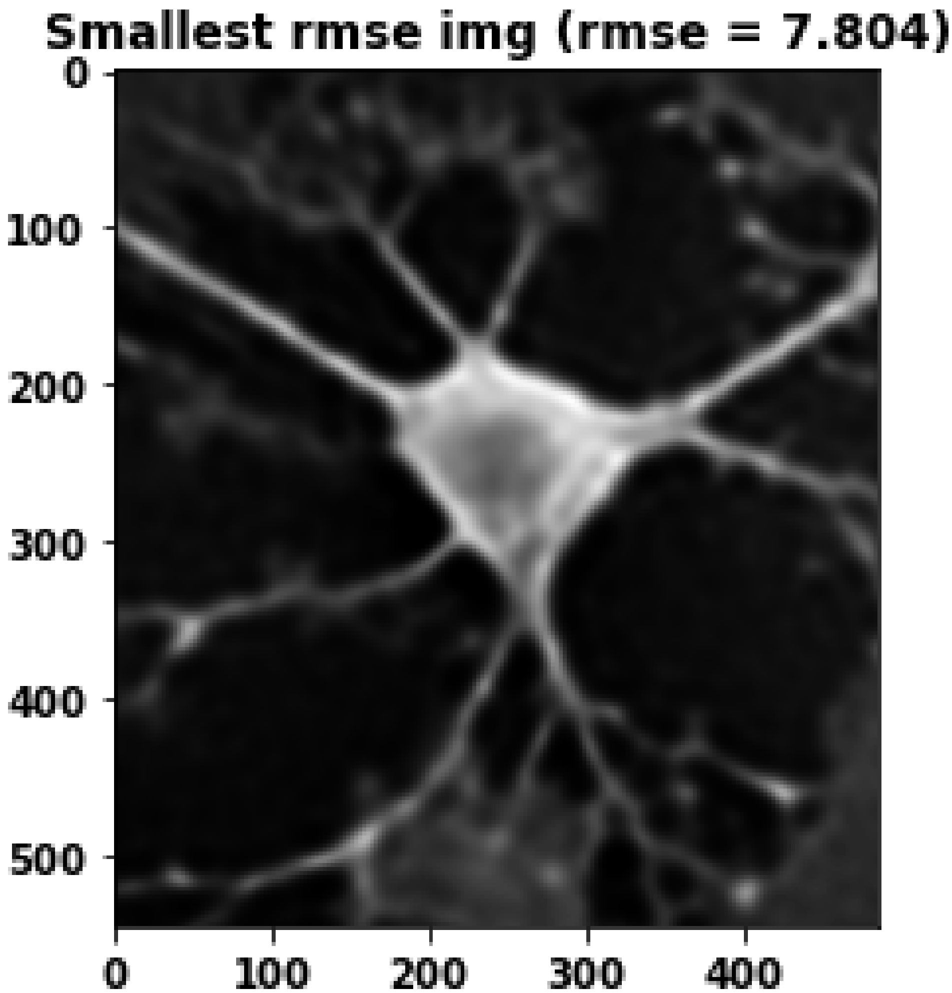


Figure 9: (e) The ‘most accurate’ deconvolved image corresponding to an RMSE of 7.804 and iterations of about 30.

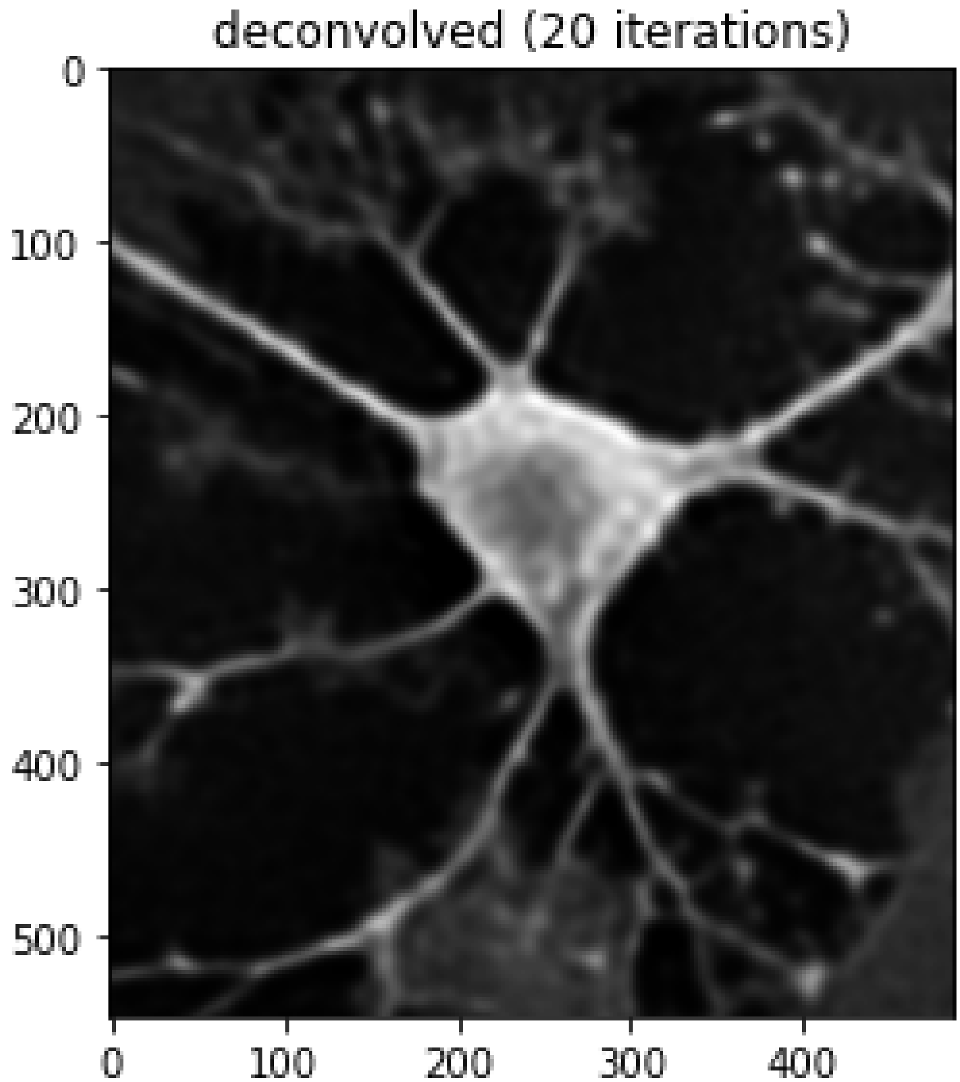


Figure 10: (f.1) The image after deconvolving it with a Gaussian PSF with $\sigma = 5$. The before and after RMSE values are given as 28.04 and 7.70 respectively. (I'm confused on this because this looks better than the previous one? Maybe I'm missing some new noise or something in the image. I think this is explained in the next part.

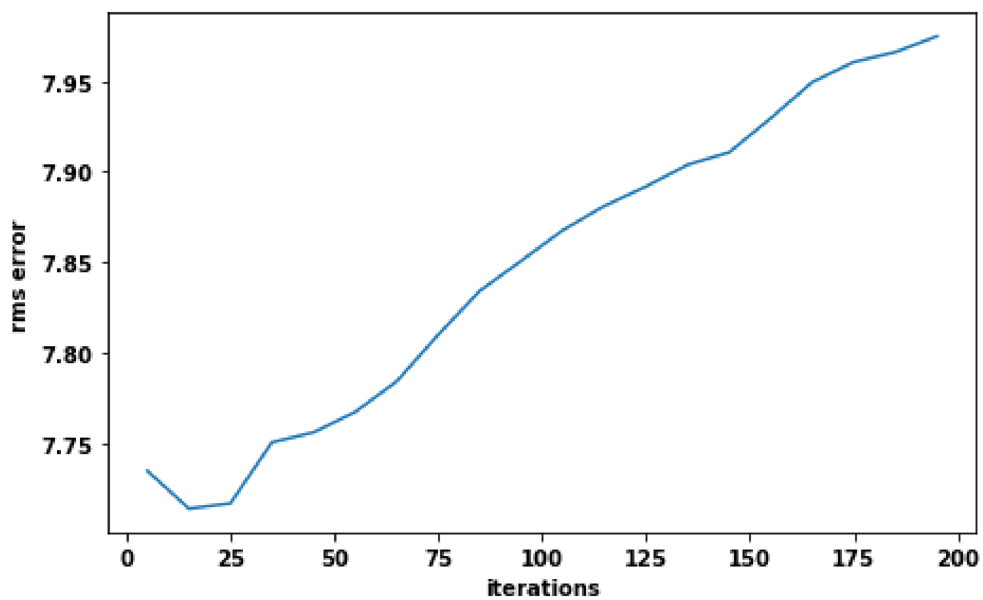


Figure 11: (f.2) While the RMSE stays low at low iterations, it quickly rises as we iterate more which would probably introduce noise we wouldn't have seen originally, going against the golden rule of "If you don't see it originally, you shouldn't see it in the deconvolution."

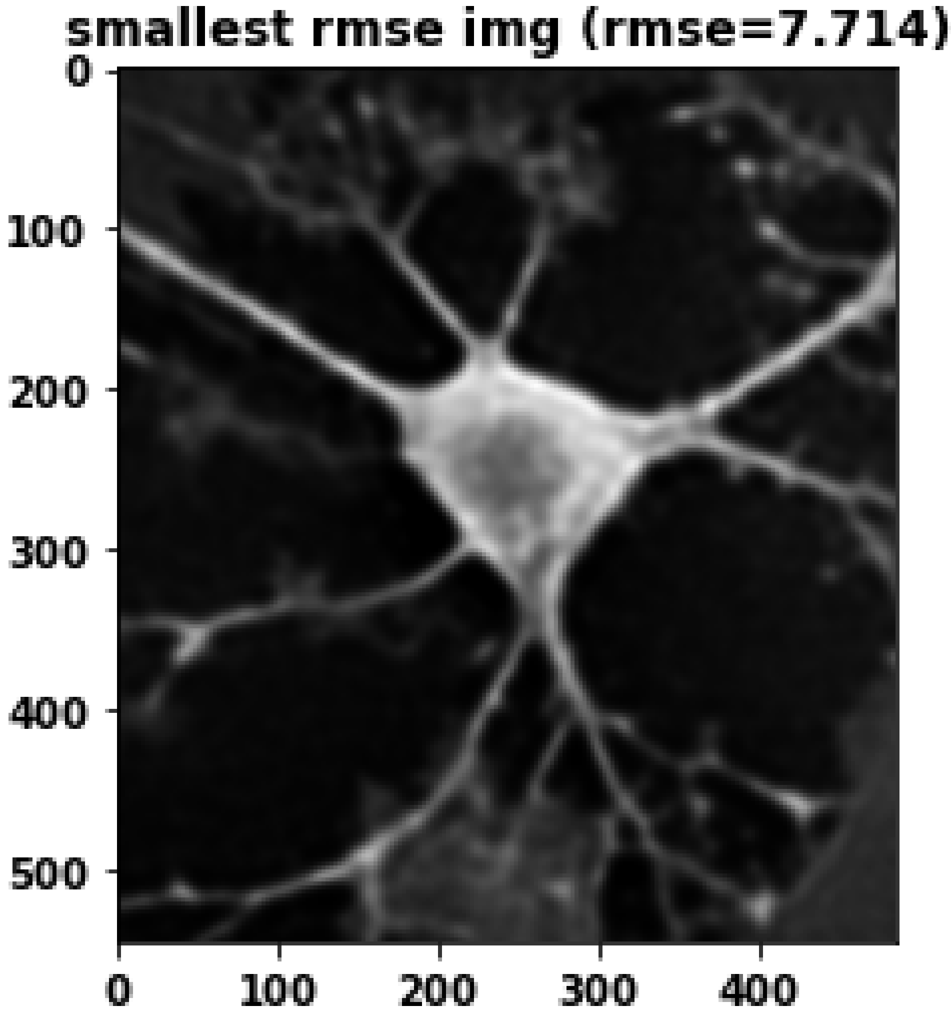


Figure 12: (f.3) The 'most accurate' deconvolved image corresponding to an RMSE of 7.714 and iterations of about 17.