

Poisson Inverse Problems by the Plug-and-Play scheme

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Deblurring using the P4IP

- Main difference : First ADMM step is not separable
- Will use an optimization method called L-BFGS to solve the optimization problem

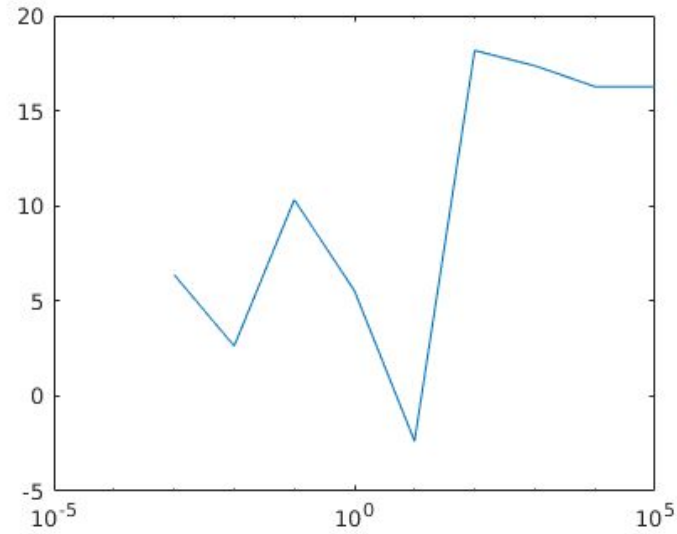
Hyperparameters

Similar to denoising, here we also have to tune hyper-parameters to get good results

We will tune **Lambda** and **Beta** both in two stages as before-

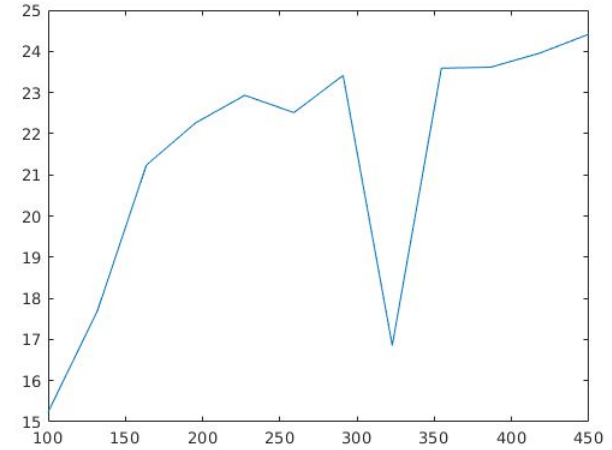
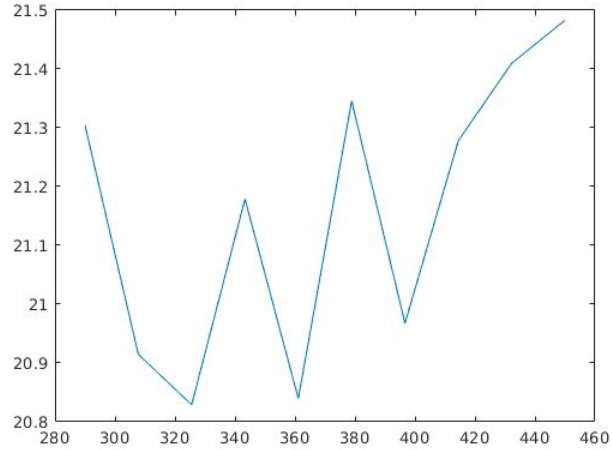
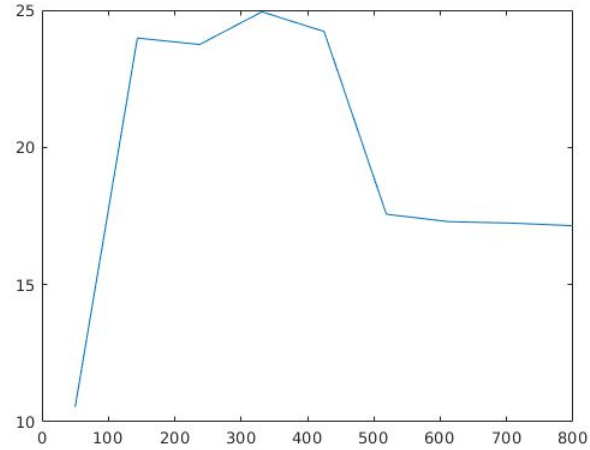
- Rough tuning
- Fine tuning

Lambda Tuning (Rough)



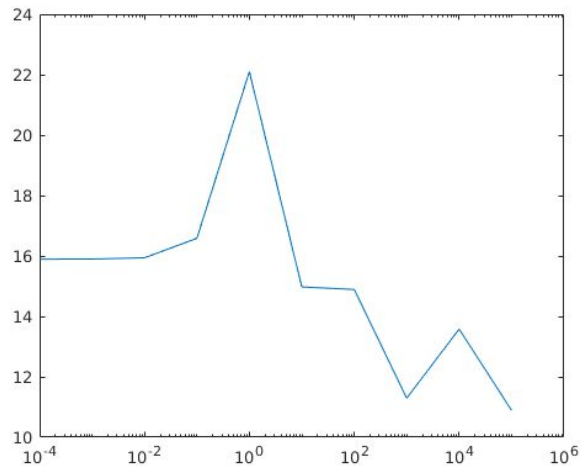
- Peak at $\lambda = 1$

Lambda Tuning (Fine)

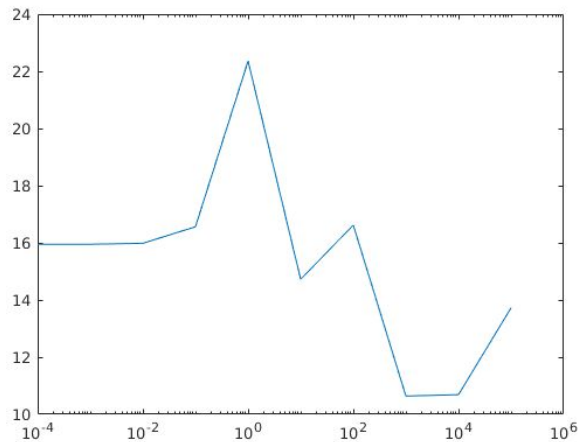


- Had to do fine tuning in three stages to get best PSNR
- Decreased epsilon as I fine tuned lambda
- Final lambda around 430-440 for peak noise = 1

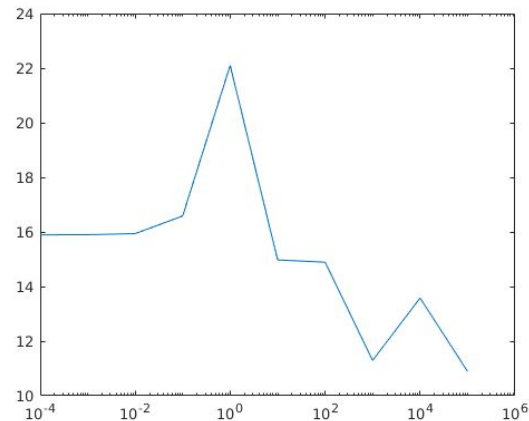
Beta Tuning (Rough)



$\lambda = 350$



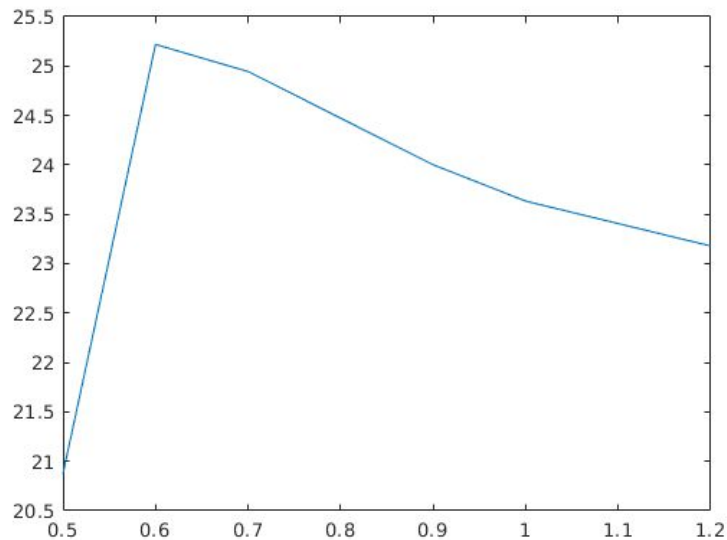
$\lambda = 400$



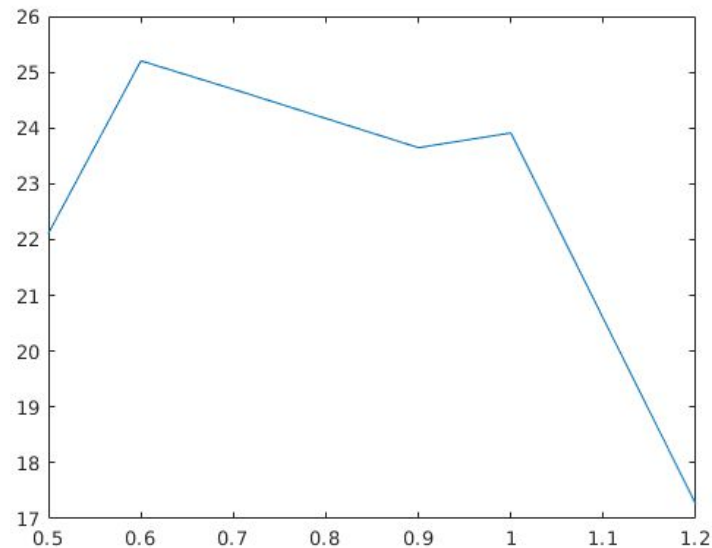
$\lambda = 450$

- Checked for multiple lambdas around optimal lambda to see trend
- Peak at around $\beta = 1$

Beta Tuning (Fine)



$\lambda = 440$



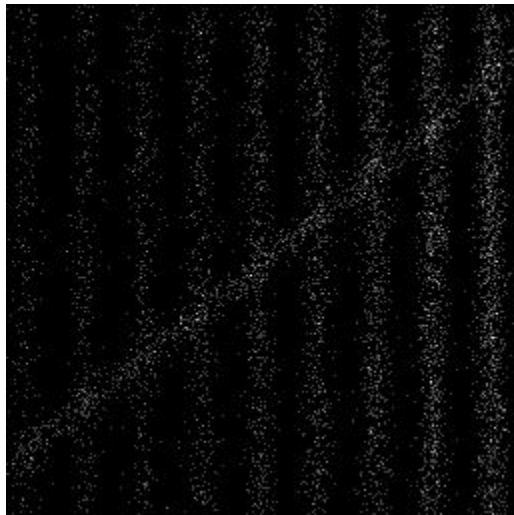
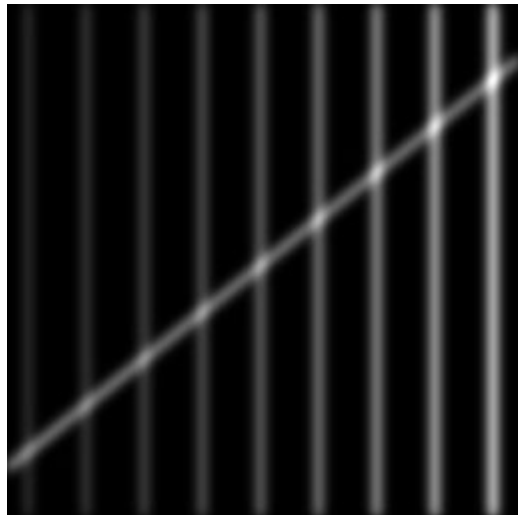
$\lambda = 450$

- Best lambda found to be 440-450
- Best beta found at 0.6

Results

- Blur kernels used
 - 25 X 25 Gaussian kernel with $\sigma = 1.6$
 - 9 X 9 Uniform Kernel
 - 15 X 15 Custom kernel with entries generated as $1/(i^2 + j^2 + 1)$ for $i, j = -7, -6 \dots 0 \dots 6, 7$
- We will show results on standard images like Peppers, Cameraman, Ridges etc

Custom blur with peak = 1

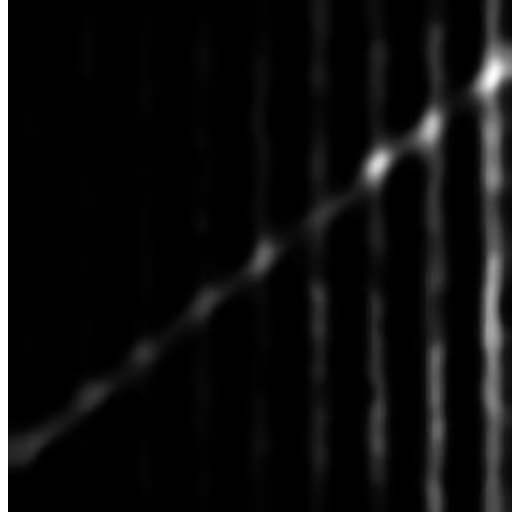


PSNR 16.1 dB



PSNR 22.62 dB

Custom blur with peak = 1 with BM3D only



PSNR 19.71 dB

This is worse than our reconstruction

Gaussian blur with peak = 2



PSNR 7.364 dB



PSNR 19.59 dB

Uniform blur with peak = 1

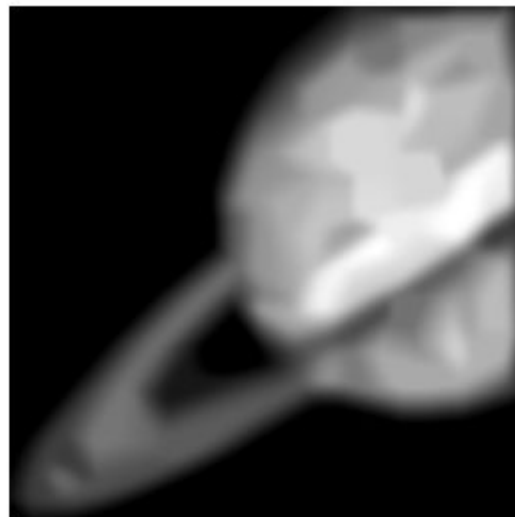
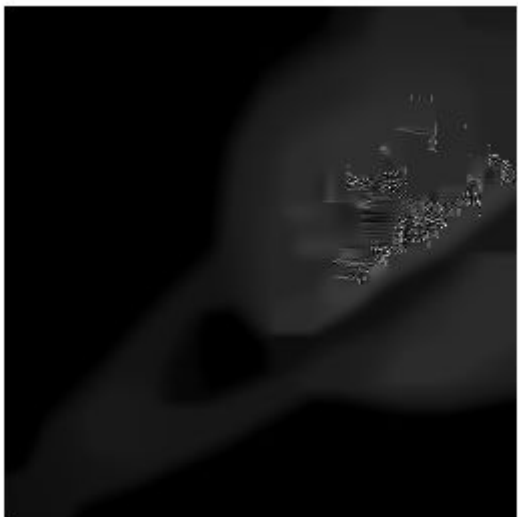


PSNR 6.86 dB



PSNR 18.45 dB

Bad Initial Guess vs Good Initial Guess



PSNR 22.919 dB

Reconstruction at peak = 1

| Kernel | Image | PSNR |
|----------|-----------|------------------|
| Gaussian | Saturn | 19.625283 |
| | Pepper | 17.967657 |
| | Cameraman | 17.929531 |
| | Ridges | 26.439523 |
| | House | 17.326899 |
| | Curve | 14.886446 |
| Custom | Saturn | 20.50723 |
| | Pepper | 18.194646 |
| | Cameraman | 16.039723 |
| | Ridges | 19.649932 |
| | House | 18.006444 |
| | Curve | 19.273641 |
| Average | Saturn | 22.919237 |
| | Pepper | 18.001448 |
| | Cameraman | 16.402292 |
| | Ridges | 20.627435 |
| | House | 17.850388 |
| | Curve | 19.067032 |

Observations/Inferences

- The hyperparameter values mentioned in the thesis of the authors do not work. It may be the case that their image representation (pixel value range) may be different which leads to different hyperparameters for us.
- As the ADMM step is not deterministic in this case, the reconstruction quality and number of iterations taken to converge is heavily dependent on the initial guess.

Improvements

- Get optimal β , λ values for different peaks and fit a curve to get a best general formula for the hyperparameters
- Try to derive an approximate closed form solution for the ADMM step to provide as an initial guess to L-BFGS