

# Image Restoration

## Assignment 2

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### Wiener Filter

Wiener Filter minimises the mean squared error to remove noise and blur. In fourier domain:

$$W(f_1, f_2) = \frac{H^*(f_1, f_2)}{|H(f_1, f_2)|^2 + \frac{P_n(f_1, f_2)}{P_{img}(f_1, f_2)}}$$

H - 2D DTFT of Blur Kernel, H\* - Conjugate of H

P<sub>n</sub> = Power Spectral Density of Noise

P<sub>img</sub> = Power Spectral Density of Clean Image

P<sub>n</sub>(f<sub>1</sub>, f<sub>2</sub>) = σ<sub>n</sub><sup>2</sup>, σ<sub>n</sub> = Standard Deviation of White Gaussian Noise

$$P_{img}(f_1, f_2) = \frac{1}{M \times N} |I'(f_1, f_2)|^2$$

M, N - Rows and columns of the image

I' - 2D DTFT of the image

## Finding wiener filter using input image on a 11x11 patch



Input Image for finding filter



Adding noise and blur to image



Filtered Image using the wiener filter

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
2	50	14.937990	2085.841824	24.560641	227.518285

PSNR - Peak Signal-to-Noise Ratio

MMSE - Minimum Mean Square Error

## Testing with new images



Test Image



Noisy Image



Restored Image

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
2	50	15.122392	1999.130583	25.741041	173.370938



Noisy Image

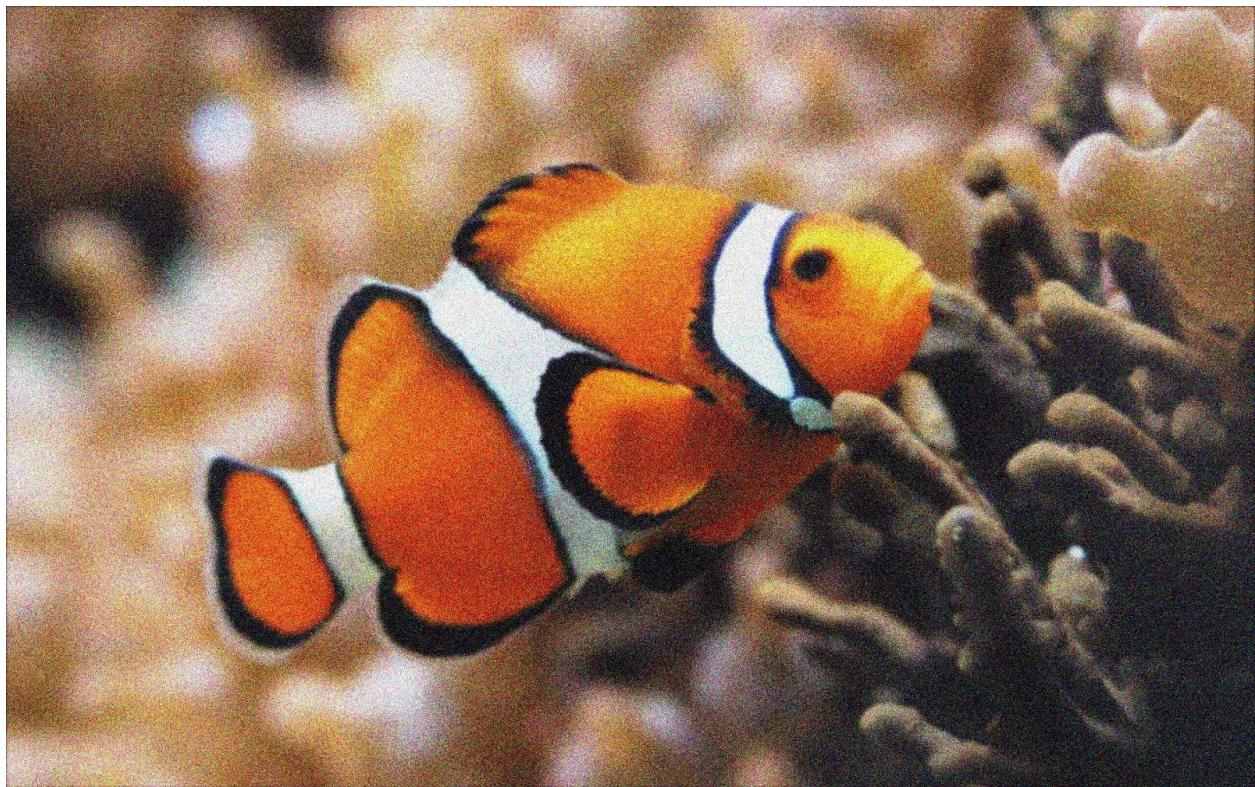


Filtered Image

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
3	60	13.755678	2738.498822	24.442152	233.811107



Input Image

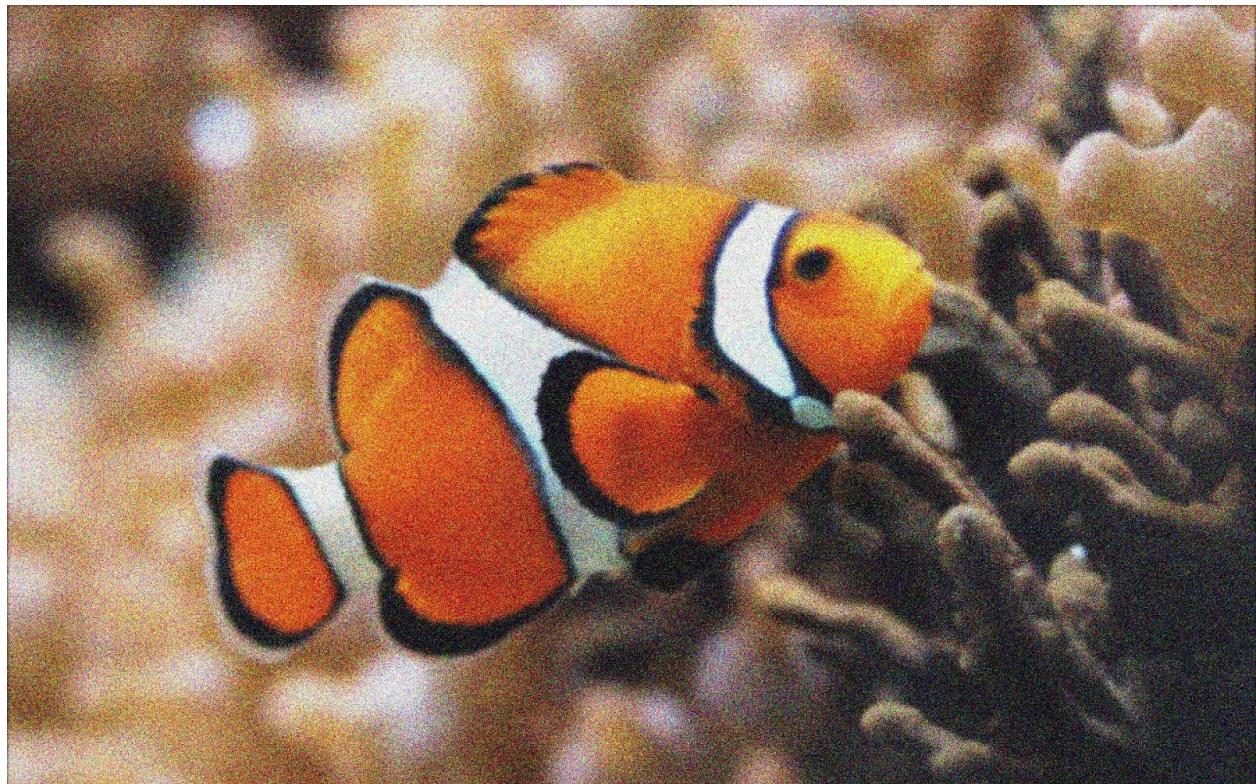


Noisy Image



Restored Image

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
2	50	15.051258	2032.144606	25.881054	167.870736



Noisy Image



Filtered Image

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
3	60	13.706075	2769.955823	24.615679	224.653122



Input Image



Noisy Image



Filtered Image

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
2	50	15.277791	1928.862250	24.726665	218.984732



Noisy Image



Filtered Image

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
3	60	13.895512	2651.729139	23.420049	295.852636

Highly Blurred and too noisy image:



Noisy Image



Filtered Image

Blur S.D	Noise S.D	PSNR (Noisy Image)	MMSE (Noisy Image)	PSNR (Filtered Image)	MMSE (Filtered Image)
20	100	10.380490	5957.051072	20.559056	571.708618

## References

- Wiener Filter -  
<https://www.owlnet.rice.edu/~elec539/Projects99/BACH/proj2/wiener.html>