Assignment 2 - Image Restoration

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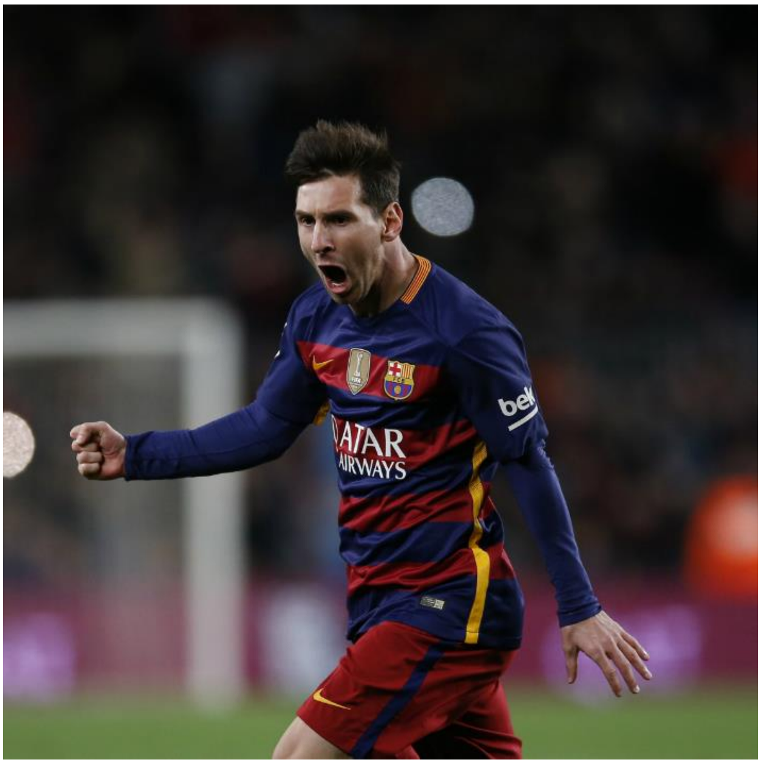
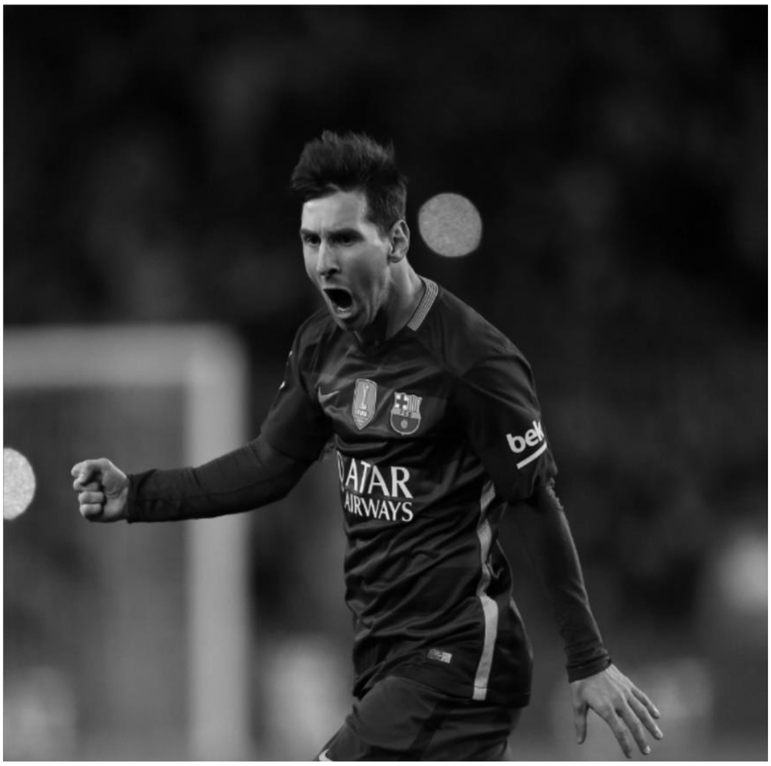
Introduction – Algorithm to restore an image corrupted by Gaussian noise and defocus blur has been implemented in this assignment. Image restoration has several important applications in the field of medical and astronomical imaging, forensic sciences etc. To implement image restoration the algorithm based upon Wiener filtering has been used. The steps involved in the algorithm are as follows:

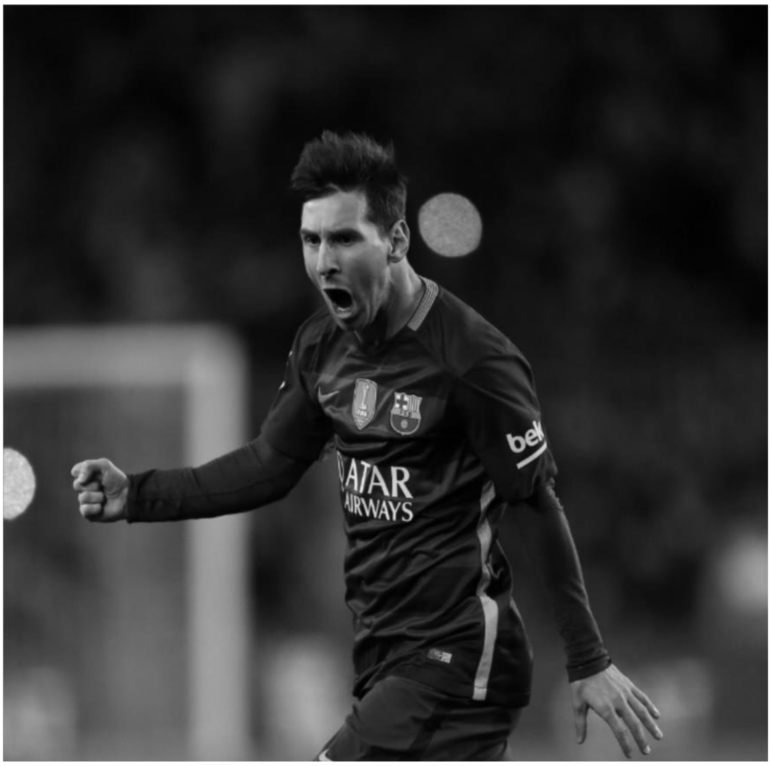
1) **Addition of gaussian noise and defocus blurring:**
    a. A gaussian kernel of size (5 x 1) matrix with variance = 0 is element wise multiplied with its transpose to obtain a 2D gaussian kernel of size (5 x 5) matrix.
    b. This gaussian kernel is convolved with the input image matrix to get an image corrupted with blurring effect.
    c. For addition of gaussian noise a matrix of the input image size with a defined variance and mean is added to the original image.

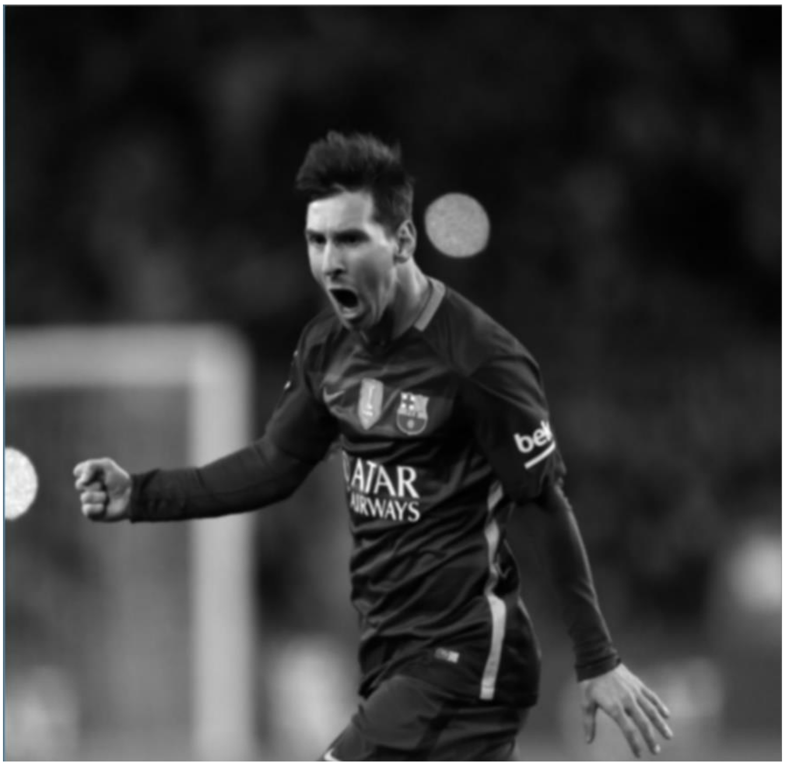
Original image in black and white –



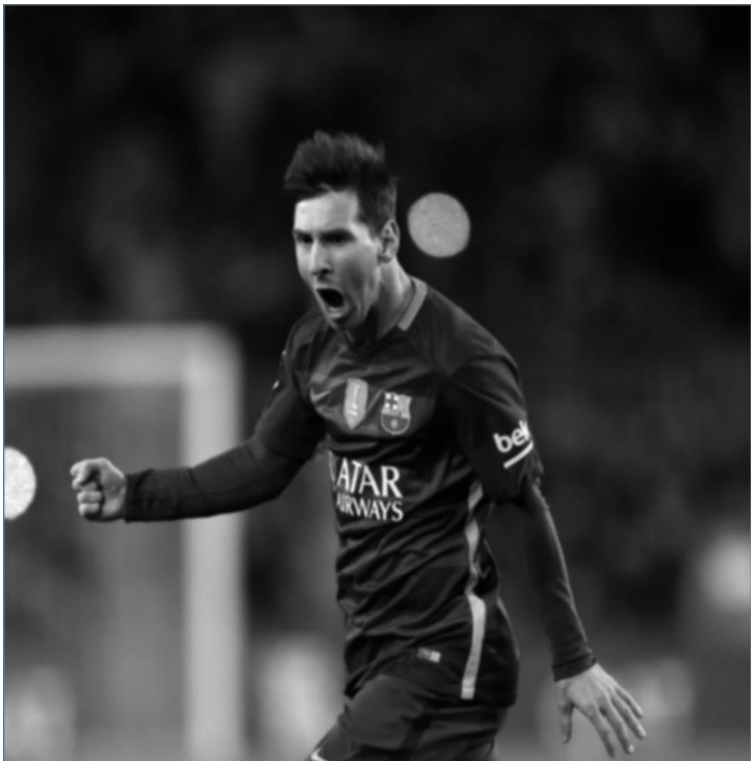


Black and white image on gaussian blurring –





Blurred image with gaussian noise addition –



2) **Filtering of the corrupted image:** The corrupted image is given by –

$$y(m,n) = h(m,n)*x(m,n) + u(m,n)$$

Where x(m,n) – Original image
u(m,n) – Gaussian noise
h(m,n) – Kernel used for blurring
y(m,n) – Corrupted image

To find the restored image, we take FFT on both sides and thus the restored image is given by:

$$\hat{X}(k,l) = G(k,l)Y(k,l)$$

Where X(k,l) – FFT of restored image
G(k,l) – FFT of inverse filter
Y(k,l) – FFT of corrupted image

Also G(k,l) is chosen such that it minimizes: $E[|X(k,l) - G(k,l)Y(k,l)|^2]$

And is thus given by:

$$G(k,l) = \frac{H^*(f_1,f_2)S_{xx}(f_1,f_2)}{|H(f_1,f_2)|^2 S_{xx}(f_1,f_2) + S_{\eta\eta}(f_1,f_2)},$$

Where $$S_{yy}^{per} = \frac{1}{N^2}[Y(k,l)Y(k,l)^*]$$

And similarly, Sxx is found from training of different natural images

3) **Gamma correction –** The image obtained after filtering is subjected to gamma correction using the function:

Output = (Image)$^{1/Gamma}$

Where the input image is scaled down to [0,1] and the output image is scaled back to [0,255]

4) **PSNR calculation –** The PSNR values for both the noisy and corrected image is calculated and given as output in the console.

Noise variance	Blur kernel variance	PSNR (Noisy)	PSNR (Corrected)
0.1	0	27.6716363895	27.715940146
0.1	0.01	27.7903818416	27.8798296953
2	0.01	27.6737741426	28.5478019935

Final corrected image –


References –

1) http://www.owlnet.rice.edu/~elec539/Projects99/BACH/proj2/wiener.html
2) https://blogs.mathworks.com/steve/2007/11/02/image-deblurring-wiener-filter/