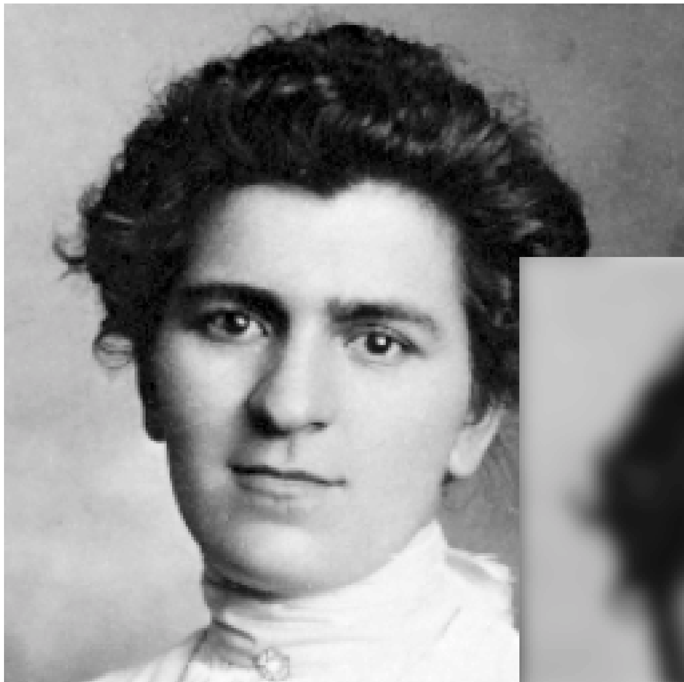
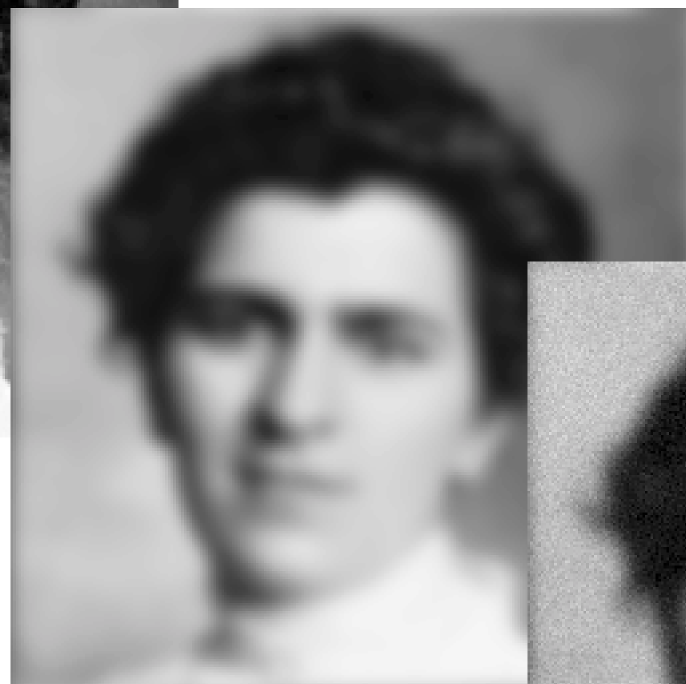
IMAGE RESTORATION II

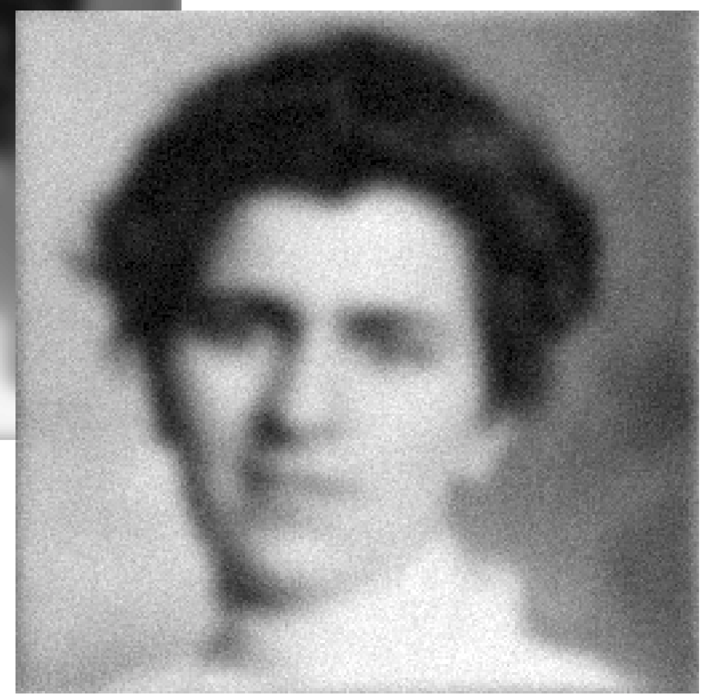
Example restoration for blur and noise



original



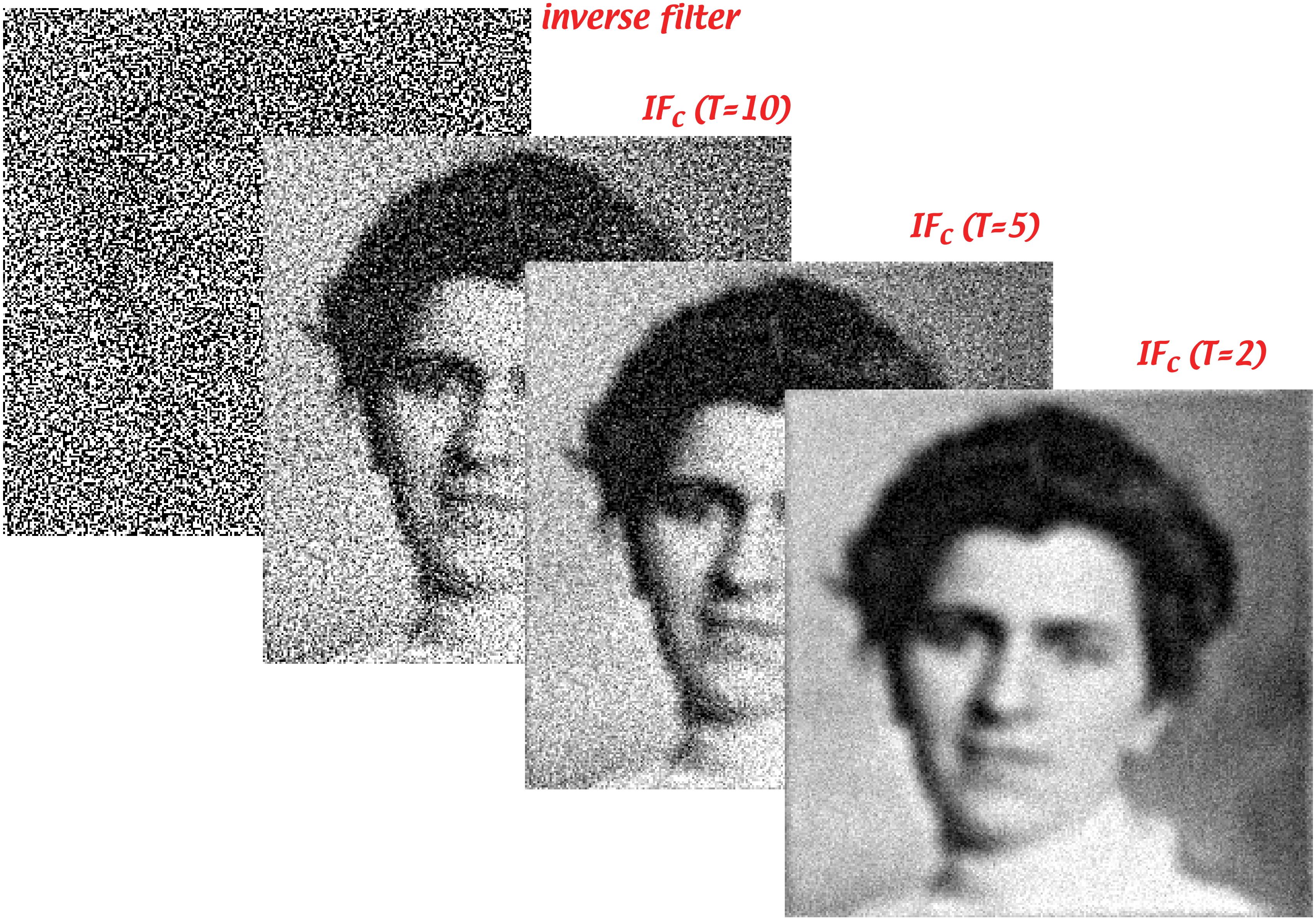
blurred (Gaussian h)



blurred & noisy

IMAGE RESTORATION II

inverse filter



inverse filter

IF_C (T=10)

IF_C (T=5)

IF_C (T=2)

IMAGE MOTION

- Assume constant velocity v, linear motion in one direction
- Impulse response is 1-D rectangle in direction of motion

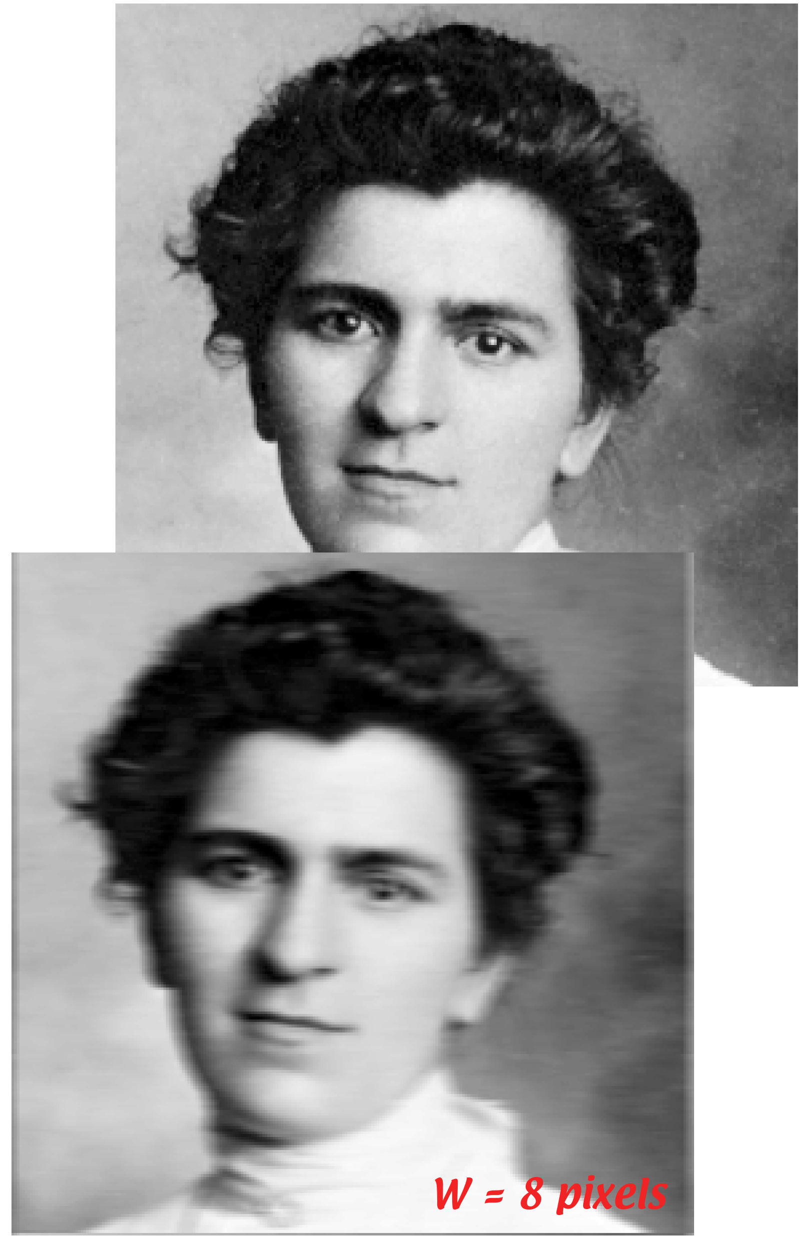
  Width W is the amount of motion during exposure time of image, $W = vt$

- Assuming motion along rows

$$h(m, n) = \frac{rect(n/W)}{W}$$ (normalized to unit area)

Write mathematical description of circular motion with constant angular velocity about center of image

How would you approach restoration of such imagery?



- ***Transfer function***

$H(l) = \mathrm{sinc}(Wl)$ ***(normalized to one at zero frequency)***

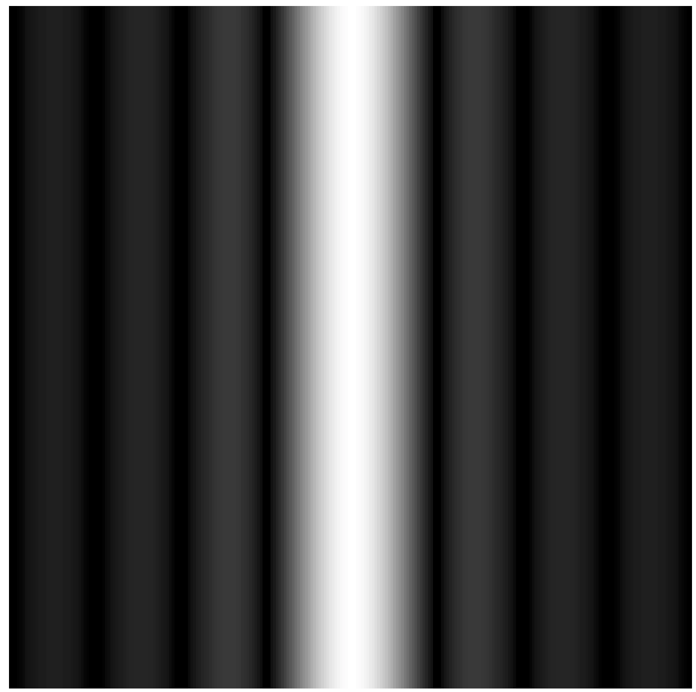
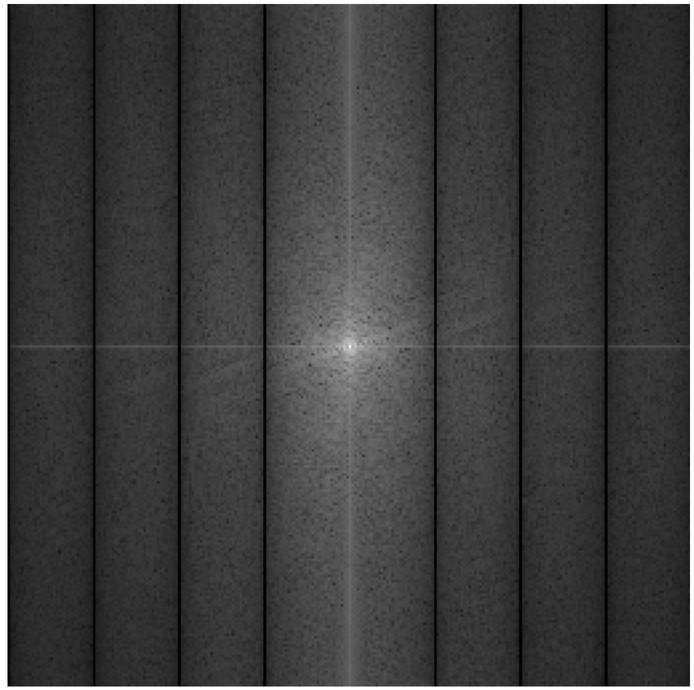


IMAGE RESTORATION II

- *Estimate amount of motion*

Use power spectrum of blurred image (either global or block-averaged periodogram)



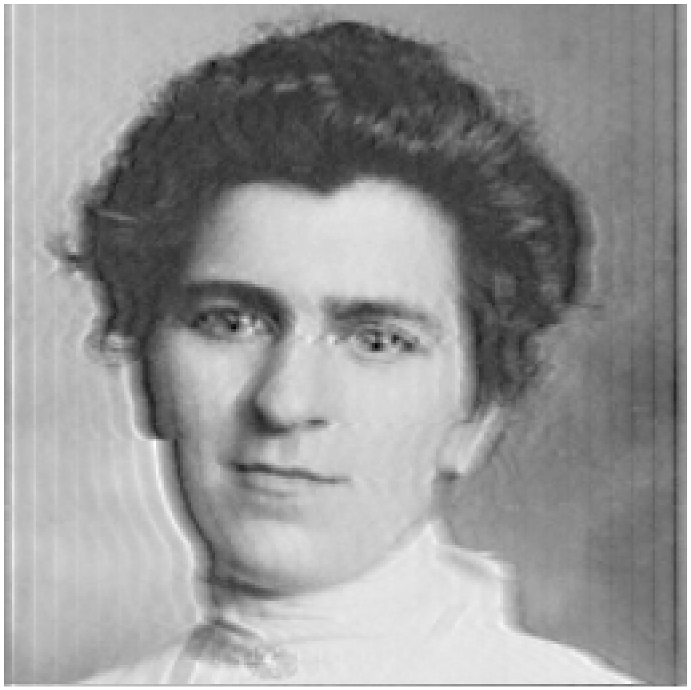
Measure frequencies at zeros, e.g. first zero @ column 161, corresponding to

$$\text{frequency} \quad l = \frac{161 - 129 \text{ (zero freq)}}{256 \text{ (size of image)}} = 32/256 = 0.125 \text{ cycles/pixel}$$

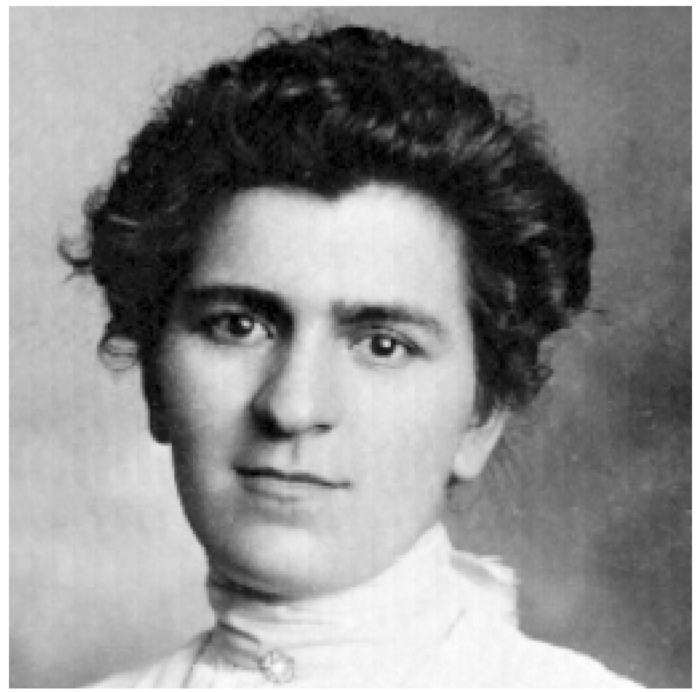
Inverse Filter

- Phase component important

Magnitude constrained to ≤ 100
with zero phase



Magnitude constrained to ≤ 100
with correct phase



What is phase component of
motion blur?

IMAGE RESTORATION II

PRACTICAL ASPECTS OF THE WIENER FILTER

Must estimate several quantities:

- **scene power spectrum P_f**

  Use model such as 1-D exponential Markov model for spatial correlation

  $R_f(h) = R_f(0)e^{-\alpha h}$, where h is the distance in pixels and α is a parameter, with units of pixels^{-1}. The corresponding 1-D power spectrum is $P_f(u) = \frac{2\alpha}{\alpha^2 + (2\pi u)^2}$

- **noise power spectrum P_ν**

  Estimate variance from uniform area of image

  Use model such as white, uncorrelated noise

IMAGE RESTORATION II

- *imaging system transfer function H*

  Use system test data (often not available)

  Measure edge or line spread functions from image targets (see notes4, p18-21) and construct estimate of 2-D transfer function H

  Use iterative "blind deconvolution" restoration techniques

  H must be estimated for any blur restoration technique, of course

REFERENCES

- Andrews, H.C. and B.R. Hunt, Digital Image Restoration. Englewood Cliffs, NJ: Prentice-Hall, 1977
- Bates, R.H.T. and M.J. McDonnell, Image Restoration and Reconstruction. Oxford: Clarendon Press, 1986
- most image processing textbooks
- Lee, J-S, "Digital image enhancement and noise filtering by use of local statistics," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. PAMI-2, pp. 165-168, 1980. (adaptive Wiener filter)
- Hunt, B.R. and T.M. Cannon, "Nonstationary assumptions for Gaussian models of images," IEEE Transactions on Systems, Man & Cybernetics, vol. SMC-6, pp. 876-882, 1976.